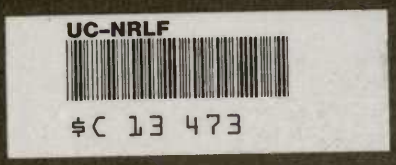
TA
422
E4

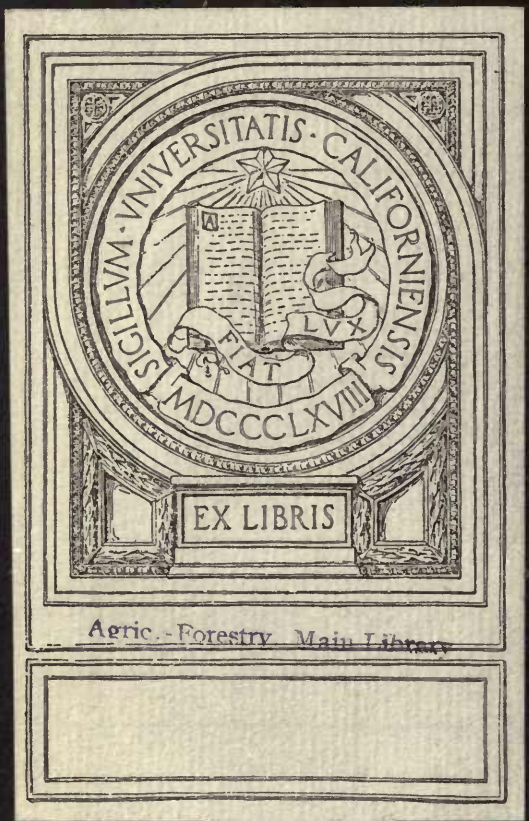


THE SEASONING OF SOUTH AFRICAN WOODS

By Nils B. Eckbo.

Reprint from The South African Journal of Industries. 1922.

YE 01350



Agric.-Forestry Main Library

COPY FOR BINDING

UNION OF SOUTH AFRICA

FOREST DEPARTMENT BULLETIN No. 5

THE SEASONING OF SOUTH AFRICAN WOODS

By NILS B. ECKBO, M.F.
Officer in Charge of Timber Investigations, Forest Department, Pretoria

(Reprinted from *The South African Journal of Industries*)

PRICE 6d.

PRETORIA
THE GOVERNMENT PRINTING AND STATIONERY OFFICE
1922

UNION OF SOUTH AFRICA

PROPERTY OF DIVISION OF FORESTRY COLLEGE OF AGRICULTURE UNIVERSITY OF CALIFORNIA

FOREST DEPARTMENT BULLETIN No. 5

THE SEASONING OF SOUTH AFRICAN WOODS

By NILS B. ECKBO, M.F.

Officer in Charge of Timber Investigations, Forest Department, Pretoria

(Reprinted from *The South African Journal of Industries*)

PRICE 6d.

PRETORIA
THE GOVERNMENT PRINTING AND STATIONERY OFFICE
1922

UNIV. OF
CALIFORNIA

TA422
E4

Agric.-Forestry. Main Library

PRINTED BY THE GOVERNMENT PRINTER, PRETORIA.
90—5.1.22—1500.

THE SEASONING OF SOUTH AFRICAN WOODS.

By NILS B. ECKBO,
Officer in Charge of Timber Investigations, Forest Department, Pretoria.

The Need for Proper Seasoning of South African Woods.

THE timber resources of South Africa are small in comparison with countries like the United States, India, Canada, etc.; still the dense indigenous forests cover about half a million acres and are certainly of great importance in the wagon industry, for colonial furniture, general building, posts, poles, sleepers, mining timbers, and fuel.

To the above acreage should be added a similar amount of scrub forest and plantations in the neighbourhood of 550,000 acres each. The plantations are mostly young, but the growth is phenomenal and some of them are rapidly reaching maturity. The thinnings are used for fencing purposes, mining, box-making, hammer handles, and fuel, and the larger trees are coming in for general building materials, wagon woods, and so forth.

However, the total yield of timber from all the forests of South Africa falls far short of supplying the local demand. Baltic deal and Oregon, the two principal building timbers, come from the Scandinavian countries and the Western United States; teak and oak from India, Burma, Eastern United States, Austria, and Japan; in fact, wood comes from most timber-exporting countries of the world. On account of the long freight it becomes exceedingly dear. Baltic deal consisting of knotty pine and spruce planks, 3 inches by 9 inches, costs from 1s. per running foot upwards; strictly clear pine, 1 inch by 12 inches, costs 1s. 6d. per running foot; and teak in heavy planks, 19s. per cubic foot.

Comparing the current prices paid for the colonial timbers it will be found that they rarely reach the price paid for poor-grade Baltic deal, and it is frequently heard that local timber is expensive at any price. Often it warps, splits or shrinks to such an extent as to cause serious losses, not only in the timber before manufacture but frequently in the manufactured articles, which means waste of material, waste of labour, and probably loss of customers.

It is for these reasons that the manufacturer prefers imported timbers that are much more reliable. It is, however, generally conceded that the inherent qualities of most of the local timbers are very good, and that the drawbacks can be largely overcome by proper seasoning methods. It is for this reason that the Forest Department, in co-operation with the Railway Administration, has started a series of seasoning experiments based on the most advanced practice of other countries.

The necessity for seasoning of timber before it can be used to the best advantage has been recognized ever since the early days when wood became a commodity of importance to mankind. To-day there are numerous methods in use, but before entering into a discussion of each one it may be desirable to consider briefly what wood really is, and what we want to accomplish by seasoning.

The Principles of Seasoning of Wood.

Wood is our most important organic structural material derived from living or dead trees. It is built up of numerous cavities surrounded by walls, resembling

495963

somewhat the arrangement of the cells in a honeycomb, but instead of being short they are drawn out to a considerable length. The cavities, or cells as they are also called, usually contain a watery fluid when the wood is green, but as the wood dries out the water is evaporated, leaving air and a small residue in its place. The cell walls are built up of a substance known as cellulose, which is permeated by a number of materials known as lignin. The walls of these cells in the green tree are saturated with water, leaving the wood soft and pliable.

(*b*) dimensions of stock ;
(*c*) stacking ;
(*d*) atmospheric conditions.

Season of Cutting Trees.

In all the northern countries of the world that are well forested the season for each logging operation is well defined. Cutting of the trees commences in the late autumn when the farm work is practically ended for the year and labour is plentiful. It may last until the snow comes or continue through the entire winter. With the first freezing weather the swamps become solid and the skidding

INSIGNIS PINE BEING SAWN UP FOR BOXWOOD.

The definition of seasoning may be said to be "dehydration with a minimum of damage to the structure of the wood."

Dehydration is comparatively easy, but the extent of damage incurred during drying determines the ultimate usefulness of the wood.

There are a great number of factors that influence the seasoning of wood in addition to the more or less complicated structure of the wood itself. Of these may be mentioned—

(*a*) season of cutting trees ;

commences. All the scattered logs are skidded or dragged by horses usually on a single bob-sleigh to large stacks, from which they are hauled on sleighs later on when the heavy snows come, to the driving stream, or possibly off-loaded on the ice of a lake. When spring opens up, the logs are floated, or driven as it is usually called, on flood waters to the sawmills, where they may be kept in booms or a mill-pond until such a time as it is convenient to convert them into planks.

It should be noted that the above procedure is often essential on account

of labour and transport conditions; but that it also coincides with the best time for cutting trees as far as seasoning is concerned is generally conceded. Since the season for cutting is considered of vital importance by a great many users of wood, it may not be amiss to consider the reasons pro and con. It is a popular belief that trees have less moisture in them in the winter, when they are said to be dormant, than in the summer; hence the saying "Sap is up" and "Sap is down." This has no foundation in fact, because it has been proven that the moisture-content is practically constant throughout the year. There is, however, a difference in the chemical composition of the sap according to seasons, and while it is believed that this has little effect on seasoning of timber, summer-cut timber is certainly more readily attacked by insects and fungi; but this, again, may be due to the fact that these agents are most active during the summer. Leaving these factors out of consideration, I think the reason for the good results of winter-seasoning is to be found in the more favourable atmospheric conditions at that time, and not on account of the internal conditions of the tree itself.

The best support for this view is that it makes practically no difference when a tree is cut, when the wood is to be seasoned in a kiln.

If this contention is accepted, the question is simplified, and it is easy to understand why the winter with slow evaporation is much more beneficial to timber than rapid surface drying during the summer.

In semi-tropical countries the seasons are much less distinct than in the north of Europe or America, and some trees seem to grow well into the winter.

Since the evaporative power of the air does not change according to seasons as much here as in the north woods, the seasonal question has a less relative importance; but since the evaporation

Assegai Wood being split for Wagon Spokes in Knysna Forests.

in the winter here may be as great as in the summer in colder regions, it will be clear that air seasoning in this country is greatly handicapped at best. It really becomes a choice of two evils—winter felling is bad but summer cutting is infinitely worse.

Dimensions of Stock.

It seems to be a deep-rooted belief in this country that wood seasons best in the bulk, and it is often heard that if logs are cut into thin boards they will warp all over the place. This contention may hold true in exceptional cases, but, as a general rule, the difficulties of seasoning wood are in proportion to the dimensions handled. It is evident that the thicker the planks the harder it is to get the moisture out from the centre and the more likelihood there is of case-hardening the stock. The tangential shrinkage of wood is always much larger than the radial shrinkage, and this fact together with uneven drying is likely to split the timber. As regards warp, it is true that a thin board is usually more inclined to warp than a heavier plank if left to shift for itself; but on the other hand it requires much less mechanical force to keep the thin board in position.

It should also be kept in mind, that as wood dries it becomes harder, which is a serious drawback. Moreover, when the planks have to be deep-cut, the pieces are very likely to warp on account of being dry on one side and not on the other.

For the above reasons it is recommended to cut the green logs into dimensions based on the ultimate use of the wood, allowing only a sufficient margin for shrinkage and planing to size.

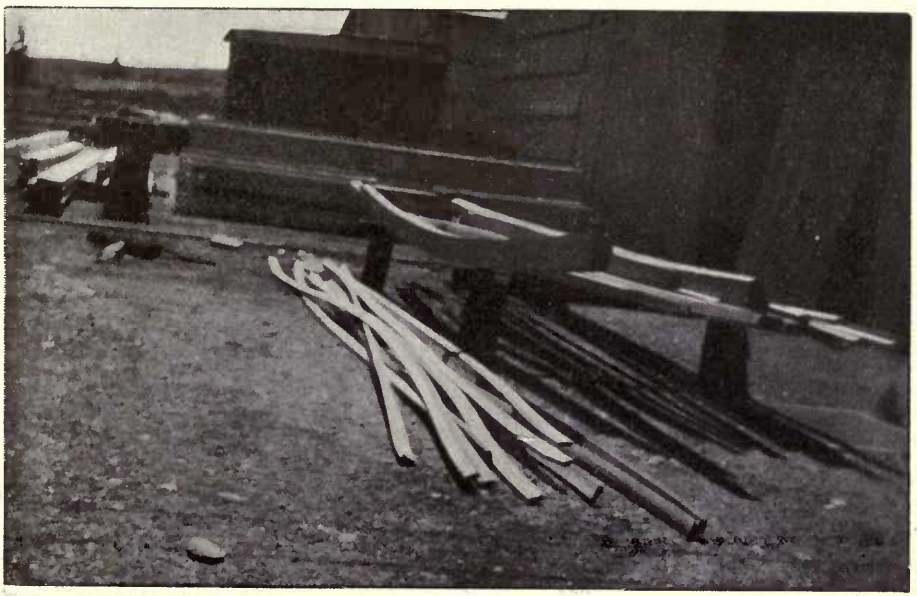
YELLOWWOOD BOARDS STACKED IN OPEN WITHOUT WEIGHTS, SHOWING SUSCEPTIBILITY OF THIS TIMBER TO WARPING.

Stacking.

Whether the sawn material is to be air-dried or kiln-dried it must be carefully stacked. The foundation should be formed by rigid supports running the full width of the pile, and preferably only 2 to 4 feet apart depending on the thickness of material to be seasoned. The air should be able to pass freely under the pile, but the supports must be close enough

together to prevent sagging. The timber should be piled in layers with cross-pieces between to afford circulation through the pile, and the top layer should be weighted down, when dealing with refractory woods, to eliminate warp as far as possible. Placing a dummy layer of dry boards on the top of the stack is an excellent plan to shield the pile from the direct rays of the sun and bad weather in general.

It should be remembered that most woods will dry straight if properly stacked and the unruly ones can usually be made to do so by mechanical means. The best example of this may be seen in bent-wood construction. The bent parts of the familiar bentwood chair are made by steaming the green wood and then drying it in any position that is desired. If the bent part is taken off and resoaked, it will be found that it may go back only a small amount if any at all.



INDIGENOUS HARDWOOD TIMBER, WARPING ON ACCOUNT OF BAD SEASONING.

Time Required for Seasoning.

This depends on the species of wood handled, the dimensions in which it is cut and the purpose for which it is going to be used. As a general rule, the soft woods or the coniferous group require only approximately one-half the time needed for the hardwoods.

The dimensions of the material, or, rather, the thickness of the planks has a direct bearing on the drying time. Two-inch planks require roughly twice as long time as 1-inch boards, and 3-inch planks three times as long as 1-inch boards, etc.

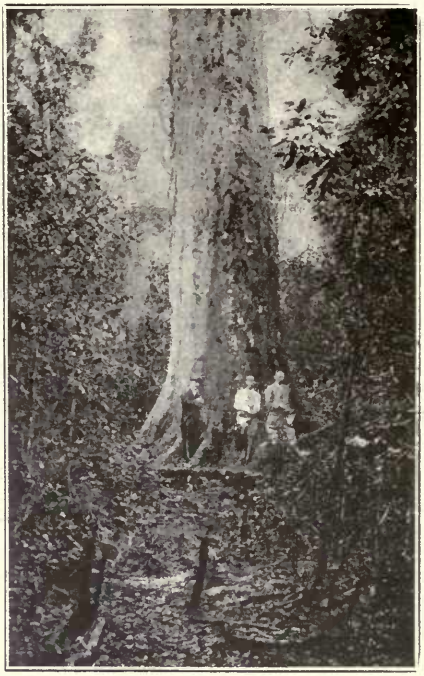
Wood used for joinery must be much more thoroughly seasoned than if the same wood were used for rough construction. One-inch oak boards for furniture manufacture in the United States are not deemed suitable in less than twelve-months' air-seasoning, and 2-inch stock requires two years or more to be reliable when air-dried. At the end of these periods the wood is frequently placed in a kiln for a few days to bring down the moisture-content still farther and to eliminate case-hardening.

When the timber is to be seasoned in a kiln green from the saw, it takes two weeks to a month per inch in thickness or less than one-twelfth of the time required for air-drying.

Difficulties in Seasoning.

The definition of seasoning seems simple enough, but a great number of difficulties are encountered during the actual process of seasoning, and in order to produce well-seasoned material it is necessary to have a detailed knowledge of them to be able to combat them effectively.

PLANTATION OF KARRI GUM AT TOKAI, CAPE. TREES ARE 2 FEET IN DIAMETER AND 110 FEET HIGH AT 30 YEARS OF AGE.



LARGE COMMON YELLOWWOOD, 10 FEET IN DIAMETER, IN STORMS RIVER FOREST, ZITZIKAMA.

The principal difficulties are as follows:—

(*a*) Case-hardening.
(*b*) Moisture-content and distribution.
(*c*) Warp.
(*d*) Fungus and insect attacks.

Case-hardening.

This defect in timber is probably the most serious, because it is invisible without tests, causes movement in articles during or after manufacture, and is most difficult to eliminate.

Case-hardening of wood is similar to case-hardening in metal, and may also take place during the drying process of fruits, leathers, etc. It is caused by too rapid surface drying. Drying being synonymous with shrinkage in timber it is fairly obvious that when the surface of any article is contracted without a corresponding contraction of the interior, the surface layer of wood must either stretch or break. The layer dried in this stretched condition becomes firmly set and has no further natural shrinkage.

This is exactly what takes place quite frequently during the seasoning process of wood; some woods stretch and others split. As the drying progresses to the centre, the interior portion tends to shrink normally until the shrinkage becomes the same as the stretched outside. As it shrinks below this point it becomes the tendency of the centre to compress the outside; and for the outside in turn to hold the centre in tension resulting sometimes in honeycombing or splitting of the interior. This condition can be readily demonstrated by sawing a series of saw-kerfs in a section of a plank.

In badly case-hardened wood it is not infrequent that the outside prong becomes half an inch longer than the inside prongs, and this is accompanied usually by a sharp curve towards the middle. A board or plank in this condition is unfit for any work of precision, although perfectly dry, because if planed more heavily on one side than the other, or deep-cut, it is certain to warp.

As long as the stresses in a case-hardened piece of wood balance each other, it may be perfectly all right to all appearances, but if at any subsequent date the case-hardening is relieved on one side of the wood and not on the other, trouble is bound to ensue.

The action of case-hardening in timber should not be confused with the somewhat similar symptoms of uneven moisture distribution, because it is far more disastrous in its effects and much more difficult to correct.

Relief can be afforded in a seasoning kiln by steaming treatments at various temperatures and of varying duration depending on the seriousness of the case.

Moisture Content and Distribution.

The moisture-content of green wood varies from about 50 to 150 per cent. of its dry weight. In other words, if the moisture-content is said to be 150 per cent., it would mean that a piece of wood weighing, say, 100 lb. when dry would weigh 250 lb. when green.

No wood, however, is absolutely bone-dry, whatever the length of time it has been seasoned. It always contains a certain amount of moisture depending on the atmospheric conditions where it is stored. Perfectly seasoned wood at the Coast would probably come down to about 8 to 16 per cent., and the same wood on the High Veld would vary between 6 and 12 per cent.

There is a further seasonal variation in the moisture-content of wood that can only be overcome by protective coatings, but since this variation is not a very serious matter in well-seasoned wood it may be disregarded.

The moisture distribution is of great importance and causes considerable trouble, particularly in deep-cut planks. Most planks contain more moisture in the centre than on the surface, unless they have been air-seasoned from six months to one year for each inch in thickness. Since most planks are used before they are thoroughly seasoned it will follow that when such a plank is deep-cut, one will have two boards that are dry on one side and moist on the other. The moisture on one side will gradually evaporate, resulting in a certain amount of shrinkage, and it is obvious that a board shrinking on one side only must move accordingly.

EUCALYPTUS LOGS, RENDERED ALMOST USELESS BY CRACKING. THIS COULD BE LARGELY PREVENTED BY PROMPT SAWING AND PROPER HANDLING.

Warp.

Twisting and cupping of timber may be grouped together as warp. It is usually due to case-hardening or uneven moisture changes in the wood, but it can sometimes be attributed to the grain of the wood, initial stresses, poor stacking, etc.

Some woods are much more susceptible to warp than others. Softwoods, as a rule, season very easily, and some of the hardwoods may be said to be almost foolproof, but others, again, like the satin walnut, bald cypress, southern swamp oaks, etc., in the United States are so addicted to warp that they were considered unmerchantable until kiln-seasoning processes were developed to render them perfectly reliable. The total output of the above refractory woods is subjected to kiln treatments to-day, and they compete successfully with other high-priced woods.

Fungus and Insect Attacks.

Wood to fungi and insects is like cake to children. A nice fresh cake appeals to them very strongly, but they would also tackle a stale one if they could not do better. Just so it is with fungi and insects—they prefer usually the freshly cut wood when it is rich in moisture, and do not often attack the dry article. Even what is commonly known as " dry rot " requires a certain amount of moisture to exist, and the fresh sap appeals strongly to many insects.

An attack by some fungi may only cause surface discolouration of timber, marring only the appearance; while others send their roots (mycelium) all through the wood, consuming the tissues as they grow until the wood is totally destroyed.

Some insects only consume the new wood and fresh sap (cambium layer) immediately under the bark; some are confined to the sapwood for their food supply; and others, again, do not discriminate at all, but devour almost any portion of the wood.

The amount of damage to wood from all the above-mentioned factors in South Africa is appalling. They have all been largely combated in other countries through improved methods of handling and seasoning, as well as by preservative treatments; and the woods of this country would no doubt respond in a similar manner.

METHODS OF SEASONING.

The methods of seasoning timber now in vogue may be grouped, roughly, as natural or air-seasoning under ordinary atmospheric conditions as against kiln-seasoning under controlled conditions.

Natural or Air-seasoning.

This method consists briefly of exposure of wood to the drying qualities of the air. For many woods this method secures satisfactory drying, and it also has the advantage of needing little equipment for its execution. There are, however, several disadvantages connected with the method that deserve consideration, the principal ones being the adverse climatic conditions in this country and the length of time necessary to effect complete drying. This means large storage space and stacking facilities, possible case-hardening and attack by fungi and insects, considerable degrade from splits and warp as well as fire danger. All these factors represent indirect cost of handling and to them should be added further the interest on capital tied up in stock and insurance premiums, if any. It should also be noted that those species that do not respond satisfactorily to air-seasoning would have to be sold at a very much reduced price in a limited market.

Artificial or Kiln Seasoning.

The history of the modern kiln is a long one. It was first introduced a good many decades ago and consisted of a room heated by an open fireplace. Timber dried much more quickly than outside, but the fire danger was great, so the stove was introduced. Drying was uneven, however, and it was found better to have the fireplace or stove outside the room and distribute the heat through the room by means of a long stove-pipe. With the advent of steam, coils were used for heating purposes, and all the above kilns are known as the " *Hotbox* " type, but there are very few of these left in existence. The lack of positive circulation of the air was found to be a weak point, and dampers were introduced to let in fresh air and for the escape of the humid air. They were based on the fact that hot air being lighter than cold air would naturally rise. These kilns were grouped together as " *Ventilated Kilns.*"

They were not found economical as far as heat was concerned, because the hot air was allowed to pass to the outside atmosphere after going through the timber. The " *Recirculating* " kiln was a great improvement in this respect. By this system the air was drawn from the drying chamber through a duct to a heater consisting of a nest of steam-pipes and then returned to the chamber by means of a fan. In this manner the same air was used continuously with the exception of comparatively small amounts of fresh air admitted at times to facilitate

INTERIOR VIEW OF A SEASONING CHAMBER, SHOWING A PILE OF HEAVY OAK VEHICLE STOCK DRYING IN A WATER-SPRAY KILN.

Note the placing of the standard thermometer and hygrometer in the entering air-flue where the conditions are ordinarily most severe.

drying. The amount of heat necessary for this method was very small, and the fan caused superior circulation. A great number of kilns of various designs were introduced, but they were all similar in their two main objects of providing heat and circulation.

The results from all the above kilns were not entirely satisfactory. They increased evaporation from the wood, but many species were found to split badly, and it became a common practice to air-season the wood thoroughly before placing it in the kiln for a final treatment. There is really no radical difference between the effect on the wood treated in these later types of kilns and that dried in the hotbox. All the wood was more or less baked according to the temperature used. The kilns were useful in reducing the drying period and bringing the moisture-content down below the amount obtainable by air-drying; but kiln-dried green wood was inferior to thoroughly air-seasoned stock. The reason for this may be made clear by making a comparison between air-seasoning and kiln-seasoning. Air-seasoning has not been entirely satisfactory because of too rapid surface evaporation, resulting in case-hardening in certain woods. In the above kilns where the surface evaporation is increased there would be all the more chance for case-hardening, and it is evident that the unfavourable conditions in nature were exaggerated.

Modern Kilns.

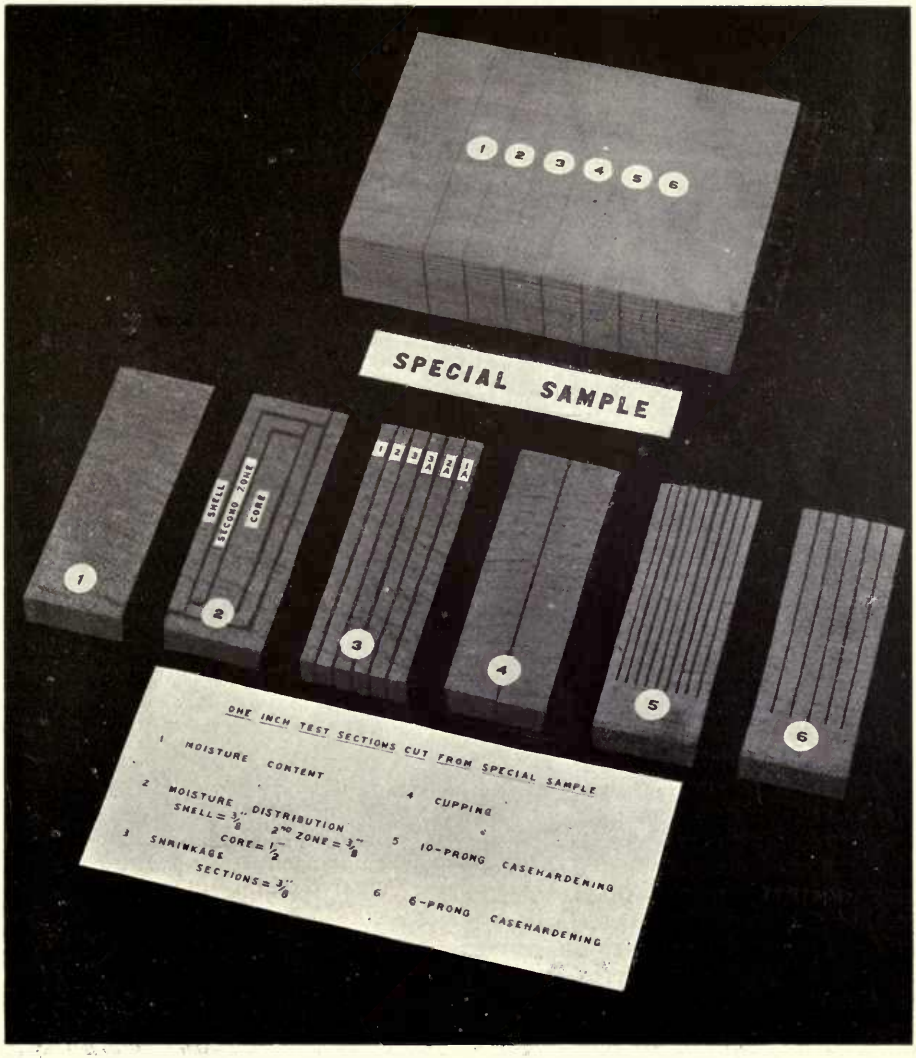
During later years, and particularly during the war, the world stock of seasoned timber ran short. Huge quantities were needed for airplane construction, artillery wheels, gun stocks, shipbuilding, railways, etc., and what little wood was available was soon exhausted. Perfectly seasoned wood, free from case-hardening and not impaired in strength, had to be found at once, and there was none—a very serious condition, to say the least. In the United States the Army and Navy turned the problem over to the trained staff of the Forest Products Laboratory at Madison, Wisconsin. It set to work immediately on a tremendous scale, seasoning timber under every conceivable condition, making thousands of tests, and, thanks to the early efforts of Mr. H. D. Tiemann, the recognized authority in Timber Physics, and his assistants, a solution was found in the "*High Humidity Regulated Kiln.*" Timber absolutely green from the saw was seasoned in record time, and, what is more, it stood the rigid quality tests demanded. Even airplane timbers were seasoned with perfect satisfaction, and the old belief that kiln-drying is injurious to strength was shattered, when the results were brought to light from some 300,000 strength tests.

The reason why the high humidity regulated kiln is superior to the old types should be explained. Wood responds to the atmospheric conditions in which it is left, and the difference in moisture-content between coast-dried timber and that seasoned on the high veld has already been pointed out. It is due to the higher relative humidity along the coast, and it may be surmised rightly that with further increase in the humidity the moisture-content in wood rises in proportion.

Another important point to establish is the difference in diffusion of moisture in wood exposed to a high humidity as against the effect of dry air. There is a distinct difference, and it may be illustrated by the effect on the human body. Most of us have experienced a summer on the high veld and one on the coast. Up here we bake and most of the perspiration from the body evaporates as soon as it reaches the surface. At a similar temperature on the coast we perspire profusely and literally dry out with a wet surface. It is just this very effect that is so beneficial in seasoning timber.

Both of these points have been introduced in the high humidity regulated kiln, and they work somewhat as follows, keeping in mind that wood may be seasoned rapidly, provided the surface does not get too far ahead of the interior.

Suppose the wood has an initial moisture-content of 50 per cent. and is to be seasoned at an initial temperature of 110° F. At this temperature and 100 per cent. relative humidity there



VARIOUS TESTS MADE DURING EXPERIMENTAL SEASONING.

The sections illustrate kiln-seasoned wood on its best behaviour and free from case-hardening.

should be no drying, but if the humidity is reduced to 95 per cent. the moisture-content will in time come down to a constant of 25 per cent. and cannot fall below this if left indefinitely. When the centre has caught up with the surface the temperature may be raised to 120° and the humidity lowered to 90 per cent., and the moisture-content would be reduced to a constant of about 18 per cent. At 130° and 80 per cent. it would reach 14 per cent. ; 140° and 70 per cent. would bring it to 10 per cent., and 150° with 60 per cent. humidity dries wood to about 7 per cent., which is as low as it is necessary to season wood. By this process the surface is never allowed to get farther ahead of the centre than the wood will stand without injury.

The above is purely a hypothetical case to show the principle worked on, and as far as actual seasoning schedules are concerned it is necessary to work them out according to the need of the individual species, their initial moisture-contents and dimensions. After these schedules have been worked out, they are easy to follow, but the operation of a kiln even then should not be mechanical by any means, because case-hardening takes place sometimes when least expected, and it should be eliminated as soon as noticed. If left without relief, the case-hardening will gradually progress towards the centre, and if allowed to proceed too far it is most difficult to relieve. The final moisture-content and distribution should also be checked most carefully before the load is removed and frequent inspections during the run are most desirable to make sure that the load is getting along as it should. As a matter of fact the success or failure of the seasoning rests entirely with the operator.

There are about a dozen different kinds of kilns on the market at the present time, most of which have been redesigned to embody all the latest improvements. They are used very extensively, and it would be difficult to find a woodworking concern of consequence in the United States to-day that does not use one or more kilns depending on their requirements. The Railway Companies, General Electric, International Harvester and the larger furniture and wagon manufacturers and others have batteries of kilns reaching as many as 96 at one plant.

The kiln has become an essential adjunct to the woodworking establishment.

A summary of the disadvantages and advantages can be made as follows :—

Disadvantages.

(1) Initial cost of kiln.
(2) Cost of qualified operation.
(3) Cost of proper storage facilities.

Advantages.

(1) Reduction of drying period.
(2) Reduction in yard space.
(3) Reduction in degrade from warping and splitting.
(4) Elimination of case-hardening.
(5) Elimination of fungus and insect attack.
(6) Proper moisture-content and distribution assured.
(7) Loss from defects in the manufactured article almost eliminated
(8) Quicker turnover on capital invested.
(9) Considerable saving in interest on capital tied up in stock subjected to long air-seasoning.
(10) Loss from fire reduced because of smaller stocks on hand.
(11) Reduction in fire insurance premiums.
(12) Order for seasoned material promptly filled.
(13) Repeat orders by satisfied consumers.
(14) General improvement in the South African grown timbers and those in particular that do not respond satisfactorily to air-seasoning.

The advantages of efficient kiln-seasoning of timber far outnumber the disadvantages, but with the business man it would be a question of relativ cost. It is very difficult to submit figures since there are only two up-to-date kilns in the country and these are both on a purely experimental scale. The equipment for the commercial kiln, 20½ ft. by 10 ft. by 10 ft., would probably be between

£250 and £500, depending on the type of equipment selected. The cost of the building would vary greatly with local conditions. A kiln on the "hotbox" pattern may be had at a very small initial cost, but since its use is limited and most of the above advantages cannot be claimed for this type, it is likely to prove the most expensive in the long run.

VIEW ALONG A NUMBER OF WATER-SPRAY KILNS USED FOR DRYING GREEN WAGON WOOD BY A PRIVATE FIRM IN THE UNITED STATES, AND SHOWING THE OPERATING EQUIPMENT AND THE SMALL DOORS FOR ENTRANCE OF THE KILN OPERATOR.

This one firm employs altogether ninety-six kilns, partly water-spray and partly fan kilns.

The cost of operating a kiln is very small, because the control is largely automatic and the steam consumption very small in a recirculating kiln. Supervision by a competent operator is essential, but he would only have to devote a comparatively small amount of his time to one or two kilns.

Taking into consideration the interest on the investment, depreciation, maintenance, steam, power, and supervision, the cost per cubic foot of seasoned timber should not exceed one shilling at the most, and it may be brought down to sixpence, depending on the local conditions.

The cost of this operation in America, where a good many thousand kilns are used continuously, amounts to threepence per cubic foot. The higher cost in this country may not seem excessive, when it is considered that the saving from advantage No. 9 alone will practically eliminate the total cost of seasoning in the kiln.

THE PRETORIA SEASONING KILNS.

The importance of improved methods of seasoning locally-grown timbers has been recognized by the Railway Administration and the Forest Department for

a long time, and it was only natural that the latter Department being the largest timber landowner and the Railway Administration being the largest user of timber, should co-operate in this work. As a result of this the Pretoria seasoning kilns were erected in the Railway Workshops, Pretoria, and duly completed February, 1921.

The Building.

The building is divided into two seasoning chambers, one operating-room, one workshop, and an office. All the outside walls are built of brick 9 in. thick, and the partition walls are 4½ in. thick. The inside is plastered throughout and given three coats of waterproof paint in the seasoning chambers.

The roof of the seasoning chambers is made of reinforced concrete 6 in. thick, which is again covered with a sheet-iron roof over the whole building.

The seasoning chambers measure 6 ft. 6 in. by 12 ft. by 10 ft. high, and were purposely made small because of the experimental nature of the work. Many failures were expected with the untried woods before successful schedules for seasoning could be developed, and larger kilns would waste more timber.

The customary size of the commercial seasoning chamber is 8 ft. or 10 ft. by 20½ ft. by 10 ft. high, except the progressive kilns, whichare much longer; but any results obtained at the Pretoria kilns could be duplicated in the larger chamber when similarly equipped. Instead of a solid brick construction a kiln may be built of (1) brick with air-spaces running in a plane with the walls, (2) brick and tile, (3) hollow tile or concrete blocks, (4) solid concrete, or (5) wood.

The kiln should be able to stand the great difference in temperature and humidity between the outside and inside conditions with a minimum of depreciation to the building; it must be a good insulator so that the inside conditions will not be unduly affected by the outside, and, again, tightness is essential to conserve the heat.

The Pretoria kilns are provided with one large loading door, three small inspection doors, and one inspection window for each chamber. The doors are built up of three layers of wood separated with waterproof paper and an air-space. The inside of the doors is covered with malthoid to prevent the moisture from penetrating the wood. They are all made like the doors on the refrigerating trucks and are giving excellent service.

The Equipment.

From several well-known types of kilns used extensively in the United States and Great Britain two were selected for Pretoria. *The Tiemann Waterspray High Humidity Regulated Kiln* was installed in one seasoning chamber. The heat in this kiln is produced by means of return bend steam coils placed under the load. To make up for variation in pressure, leaks in the building and the effect of changes in atmospheric conditions surrounding the kiln, a thermostat is used to keep the temperature constant in the chamber regardless of the disturbing factors mentioned. The thermostat consists of a valve on the steam line, which is operated by liquid, gas or vapour-filled bulbs on the inside of the chamber through a hollow cable. This instrument may be set at any desired temperature, and whenever the temperature rises above this point, the contents in the bulbs expand and close the valve. If, on the contrary, the temperature falls in the kiln, the contents contract and open up the valve. This is a most useful instrument in the operation of the kiln, ensuring a steady control.

Circulation is effected by a series of watersprays running along one side of the chamber placed 11 in. apart. A pressure of 50 lb. is kept on the sprayheads, forcing the water down into a sump under the load, from which it runs to a well on the outside of the kiln. From the well it is pumped back into the sprays again and recirculated in this manner. When the sprays work freely at the right pressure, a circulation of about 50 ft. per minute is obtained through the pile of timber.

Variation in humidity in this kiln is obtained by changing the temperature

of the water. The colder the water, the lower will be the humidity and, in addition to regulating the humidity in the kiln, the sprays serve a valuable purpose as condensers. The surplus moisture in the hot air is forced to condense when it strikes the cooler sprays, and the amount condensed in turn affects the humidity. If the humidity cannot be lowered sufficiently with the sprays, it is possible to make use of condensers, and if a steam bath is desired to relieve case-hardening, a perforated pipe is made use of, which fills the chambers rapidly with steam. A few heating coils are placed under the ceiling, and these are used to eliminate condensation dropping from the ceiling.

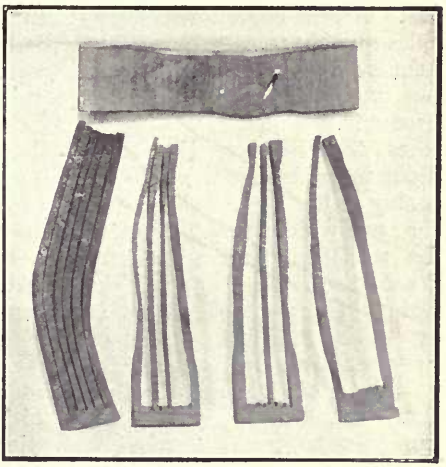
This kiln is used extensively in the United States and has lately been introduced by the Governments of Australia and India.

The other kiln selected for Pretoria is called the *Sturtevant High Humidity Kiln,* and was installed in the chamber adjoining the water-spray kiln.

The heat in the Sturtevant kiln is produced in a nest of steam-heated coils, covered by a metal housing, and placed in the operating-room a short distance from the end of the kiln. The heat from these coils is forced into the seasoning chamber through a box or duct by a fan that is operated by a motor. The box or duct is about 12 in. by 12 in. in cross-section and runs the full length of the chamber. The wall and floor form the side and the bottom of the box; the other side may be made of concrete or wood, and the top can be made of wood or metal. It should be perforated in such a manner as to distribute the air evenly throughout the chamber. On the opposite side of the chamber is a similar duct perforated in the same way. This duct serves the purpose of withdrawing the air from the chamber to let it pass by the heating coils again to be reheated. The fan gives a very positive circulation throughout the chamber and to regulate the distribution it is possible to change the size of the perforations or vent holes.

When the air becomes too humid, it is necessary to let some of it escape and substitute drier air from the atmosphere. This is accomplished with a vent stack on the leaving duct. By means of two dampers it is possible to throw the air to the heater or to the atmosphere at will. By opening a damper on the heater housing, fresh air may be taken in.

It is not very often that the air becomes too humid in the kiln; on the other hand, it ordinarily is too dry, and means must be provided to increase the moisture. This is accomplished in the Sturtevant kiln by introducing a steam-jet inside the heater housing. The humidity is then regulated by allowing live steam



Badly Seasoned Wood, Severely Case-hardened.

The sections were square before cutting. Note the difference in the lengths of the prongs.

to mix with the hot air after it passes over the coils, but before it enters the chamber.

A steam-bath is provided the same way as in the water-spray kiln and also ceiling coils for the elimination of condensed water dropping from the ceiling.

The conditions are thermostatically controlled, ensuring steadiness and even drying.

The Sturtevant kiln has been on the market for a very long time, and is widely represented throughout the world. The latest types have been greatly improved and are capable of seasoning refractory woods with good results.

Both the kilns are provided with recording and non-recording hygrometers. The recording hygrometer makes a continuous record of the temperature and humidity in the kiln, and the non-recording instrument is used as a check. It is necessary to have one of these instruments to enable the operator to run according to specified schedule.

In addition to the equipment used in connection with the actual running of the kiln there is a certain amount of auxiliary equipment necessary to ascertain the condition of the load. The electric flashlight or any other kind of light is necessary to inspect the load during the seasoning period. A small oven to dry out small samples quickly to ascertain the moisture-content is very useful, and scales are necessary in this connection to obtain the weights.

Access to a bandsaw should be had to cut up case-hardening discs. The Pretoria seasoning kiln is provided with three trucks on which to stack the timber to be seasoned, and sufficient stickers to keep the boards or planks apart. The third truck is loaded up while the other loads are being seasoned, and when one is ready to come out it is only a matter of a few minutes to exchange trucks. The kiln is also equipped with instruments to measure wind velocities inside the kiln, shrinkage in wood, specific gravity, the working qualities of the woods, and so forth, but a great deal of this equipment is only necessary in an experimental kiln and would not be needed in commercial practice.

Operation of the Seasoning Kilns.

The object of the work at the seasoning kilns is to demonstrate the feasibility of seasoning South African grown woods and prepare schedules that may be used by commercial firms having the necessary equipment.

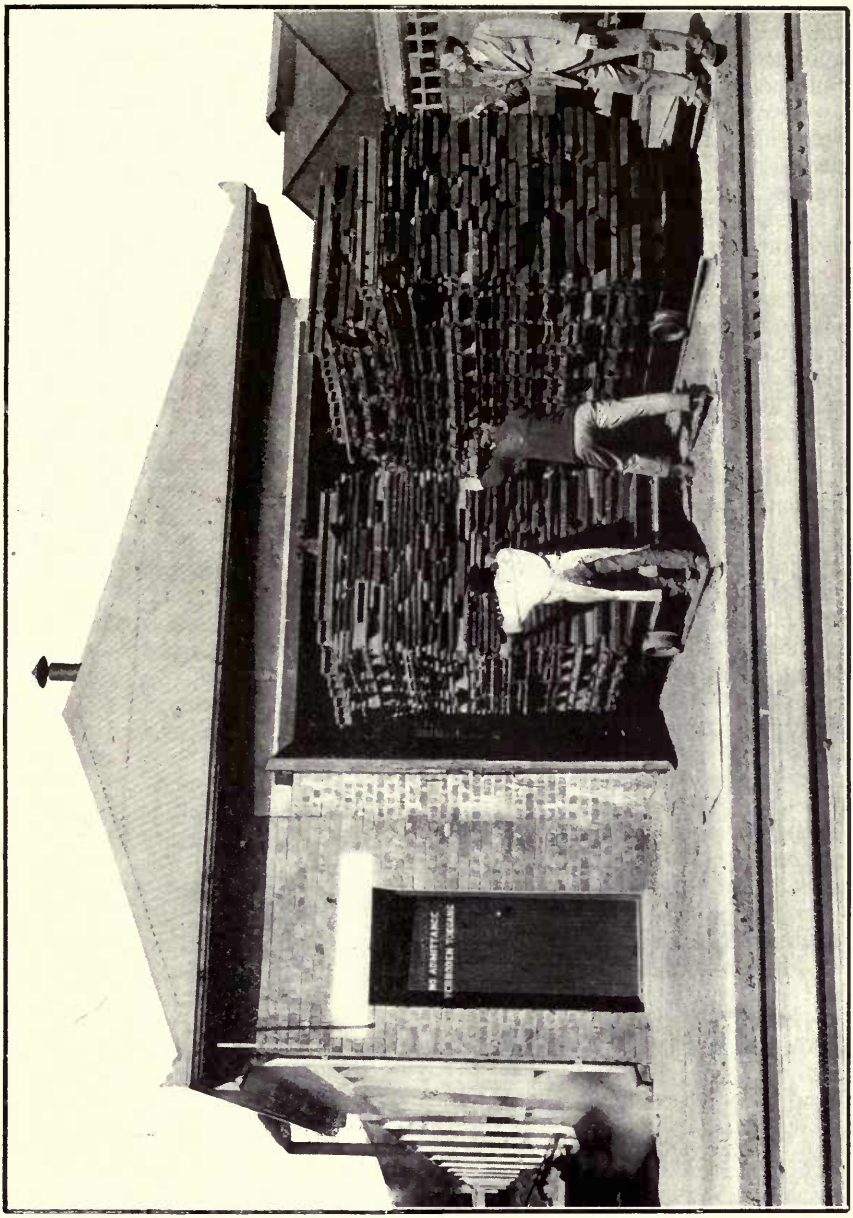
A programme has been worked out covering the most important species, and the trees are cut from time to time and shipped to Pretoria as it becomes possible to deal with them.

The kilns are very conveniently located in the Railway Workshops near the Pretoria Railway Station. The wood coming in is sawn up in the sawmill, loaded on the trucks, and pushed into the kiln. The load is then given a steaming treatment of one to twenty-four hours at 140° to 180° F. depending on the species, thickness of the planks, and whether the wood is case-hardened. This initial steaming serves the double purpose of heating the wood through to the centre without cracking it, and relieving any case-hardening that might be present.

The temperature is then dropped to 110° to 150° F. and the humidity to 85 per cent. to 95 per cent., and drying should take place at the rate of 3 per cent. to 5 per cent. per day. After a few days under the above conditions, the drying rate will fall off, and it is necessary to raise the temperature and lower the humidity until the final drying temperature is reached at from 130° to 180° and the humidity is reduced to 40 per cent. to 60 per cent. Case-hardening is demonstrated by deep-cutting planks or sawing several kerfs in a narrow cross-section of the plank. If the boards or prongs cup towards the centre or the outside prongs are longer than the inside prongs, the wood is case-hardened. This defect is almost certain to develop during the seasoning process sooner or later, and the operator must be on guard to eliminate it promptly. Steaming treatments are used as remedies, and it happens frequently that a load has to be steamed four or five times before the case-hardening is relieved.

A very close track is kept of the moisture changes in the wood, both the total rate of drying and the distribution of the moisture in the pieces; because it is very important to season the wood to the correct moisture-content and to safeguard against too rapid surface evaporation. The moisture-content of any piece of wood is easily found by weighing the green wood, reweighing when the wood is absolutely dry, dividing the difference by the dry weight and multiplying by 100. This will give the moisture in percentage of the dry weight of the wood.

It is aimed to get an initial drying rate of from 3 per cent. to 6 per cent. every



THE SEASONING KILNS AT THE RAILWAY WORKSHOPS, PRETORIA.

One load of indigenous wood has been taken out after seasoning and another load, green from the saw, is being pushed in for treatment.

twenty-four hours, and as the wood gets drier, the rate comes down gradually to 1 per cent. to 2 per cent. When the wood has reached an average of 7 per cent. moisture and no case-hardening is present, the run is shut down. At this moisture-content the wood is suitable for joinery without running a risk of shrinkage on account of too much moisture in the wood.

Daily shrinkage measurements are made to determine the total shrinkage of the different species, and when the load has reached the desired moisture-content, it is carefully examined in order to determine the amount of damage, if any, that may be charged against the seasoning process. Soon afterwards, it is issued to the various workshops for immediate conversion into the finished product, and a record is kept of the behaviour of the woods in the manufactured state.

Kiln-Seasoning of Yellow-Wood.

A programme of the seasoning work to be carried out was prepared, comprising some of the most important indigenous as well as exotic species with the idea of extending the list to the less important species from time to time. By far the most abundant and generally useful indigenous wood is the yellow-wood, which was placed foremost for treatment. Of this wood there are three species: Common or Outeniqua yellow-wood (*Podocarpus elongata*), real or upright yellow-wood (*Podocarpus Thunbergii*), and falcate yellow-wood (*Podocarpus falcata*). They are well represented in most of the indigenous forests in the Union, and from the Government forests, yield more timber than all the other indigenous species taken together. A few average trees of all the three species of yellow-wood were selected by forest officers in different parts of the country, cut into logs 12 ft. long, and shipped to Pretoria with ends painted to prevent end-cracking.

Seasoning of Falcate Yellow-Wood

(Podocarpus falcata).

The first lot to arrive was falcate yellow-wood, and this was sawn into boards $1\frac{1}{8}$ in. thick by any width that the logs would allow and 12 ft long. The logs sawed up very well, showing no cracks nor internal defects of any consequence and yielded clean boards free from knots.

The boards were loaded on the kiln-truck with stickers 1 in. square and $4\frac{1}{4}$ ft. long, placed 2 ft. apart between each layer of boards so as to ensure free passage of air-currents through all parts of the load, the whole forming a pile $4\frac{1}{4}$ ft. wide, 7 ft. high by 12 ft. long. Ten samples were cut from the green boards and placed on each side of the load to ascertain the initial moisture-content of the wood and the rate of drying during the run. The moisture-content of the individual samples varied from 53·7 per cent. to 87·4 per cent., averaging 70 per cent. of the dry weight. In addition to the samples that were weighed every day during the run, a number of control pieces were placed in different parts of the load to be cut up at intervals for case-hardening and moisture distribution tests. It should be clear that all these samples and control pieces are not necessary in a commercial kiln, but only in experimental plants where seasoning schedules are being worked out.

One ton of short rails were placed on the top of the load to keep the top layers of boards from warping, the truck was pushed into the Sturtevant or fan kiln and the actual seasoning treatment commenced the 1st of February, 1921.

The load was steamed for one hour at 174° F. to warm up the timber as well as the kiln in a short time without damaging the wood. The temperature was then brought down to 130° F. with a humidity of 86 per cent. when the drying commenced. In the first seven days the temperature was gradually increased to 147° F. and the humidity reduced to 61 per cent., and at the end of this time there was a drop in moisture-content from 70 per cent. to 22 per cent., or an average of 7 per cent. per day with a corresponding total shrinkage of 2·5 per cent.

The relatively small shrinkage is due to the fact that the free water contained in the cells evaporates before the water located in the cell walls and until the free water is all evaporated there should be but very slight shrinkage. The point

at which the cell walls of the wood are saturated with moisture is called the fibre saturation point, and it is ordinarily found in wood containing from 25 per cent. to 30 per cent. moisture.

At the end of the first seven days, it was found that the case-hardening prongs commenced binding very slightly on the saw, which is a sure sign that case-hardening is present. The load was therefore promptly steamed for one hour at 195° F., and drying resumed at 150° F. and 62 per cent. humidity. The steaming only gave temporary relief, and it was found that the control pieces showed signs of case-hardening again after another three days' drying, when the temperature had been raised to 168° F. and humidity lowered to 57 per cent. This time the symptoms were much more pronounced, showing that the effect had penetrated the surface of the wood to a depth of approximately $\frac{1}{8}$ in. Therefore the wood was steamed for three hours at 196° F. to afford relief at the greater depth, and drying was continued at 172° F. and 57 per cent. humidity. At this time, after ten days of drying, the load had reached an average of 13 per cent. moisture and showed 3·4 per cent. shrinkage. While this might have been sufficiently dry for rough outside use, it would be certain to cause trouble on account of further shrinkage in the case of wood used for joinery work.

For the six days following the second steaming treatment, the temperature was kept at from 172° to 177° F. with a humidity from 62 per cent. to 32 per cent. This brought the load down to an average moisture-content of slightly less than 7 per cent. (with a total shrinkage of 4·1 per cent.), which was thought to be a suitable condition of seasoning for wood used on the High Veld.

The control pieces showed a slight tendency to cup towards the centre, and the load was steamed for two hours at 196° F. which relieved practically all the remaining stresses. This really completed the seasoning process in sixteen days; but the load was left two more days, as indicated on the graph, for a final conditioning or balancing of the moisture distribution. The latter treatment is not of vital importance because, if the wood is sufficiently dry when coming from the kiln, the conditioning

Daily Record.

Species: Falcate yellow-wood, $1\frac{1}{8}$ in. Run No. 1. Date: February, 1921.

Date.	Temperature.	Humidity.	Steaming.		Moisture Content.	Shrinkage.	Remarks.
			Hours.	Deg. F.			
	Deg. F.	Per cent.			Per cent.	Per cent.	
Feb. 1	130	86	1	170	70·0	—	Run started 7 a.m.
,, 3	130	86	—	—	50·0	—	
,, 4	130	83	—	—	46·3	0·8	
,, 5	138	75	—	—	40·0	1·4	
,, 6	145	65	—	—	33·3	1·7	
,, 7	147	61	—	—	26·6	2·2	
,, 8	148	64	1	195	21·9	2·5	Slight case-hardening.
,, 9	155	58	—	—	16·7	2·9	
,, 10	165	64	—	—	14·6	3·2	
,, 11	168	57	3	196	12·7	3·4	Severely case-hardened.
,, 12	172	57	—	—	11·3	3·6	Case-hardening removed.
,, 13	174	62	—	—	—	—	
,, 14	177	56	—	—	9·8	3·8	
,, 15	175	34	—	—	9·0	3·9	
,, 16	173	36	—	—	7·9	4·2	
,, 17	175	32	2	196	6·9	4·3	Slight case-hardening.
,, 18	173	42	—	—	7·4	4·3	Conditioning of load.
,, 19	175	27	—	—	6·4	4·6	Kiln closed down 1.30 p.m.

might be left to ordinary air surroundings, but if the wood is to be used immediately the short additional treatment is desirable.

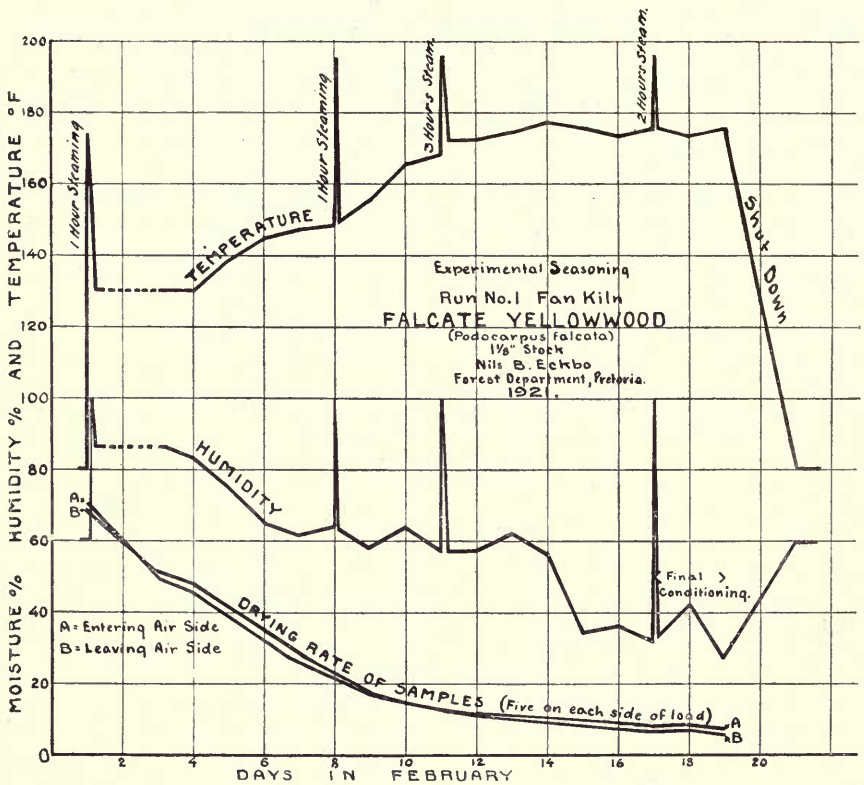
A copy from the daily record follows, which gives the temperature and humidity conditions obtained throughout the run, and the steaming treatments, and reflects the effect on the moisture-content and shrinkage of the wood.

The treatment given is also shown in the diagram or graph.

One of the most important considerations or guides in working out seasoning

After the kiln shut down, all the samples were extracted and cut up to show their actual moisture-content, distribution, and condition in regard to stresses, and the figures are shown in the table below.

It will be noted that in the majority of the samples the effect of the steaming carried out a couple of days before the end of the run is reflected in the slightly higher moisture-content of the surface as compared with that of the centre. The final condition of the samples shows



schedules is the rate of transfusion of moisture from the centre to the surface of the wood.

A great number of control pieces were cut up for this purpose, and the maximum difference was found on the 8th of February, when one control piece contained 37·7 per cent. moisture on the surface and 48 per cent. in the centre. It was at this time the load was steamed, resulting in equalization of the moisture in addition to the relief from case-hardening.

a maximum difference in moisture-content between the whole test sections of 2·3 per cent. and a maximum difference between the surface and centre moisture of 1·1 per cent. These figures are well within the allowable range of variations in the seasoned load, which is usually placed at 4 per cent. in the first instance and 1·5 per cent. in moisture distribution.

The average drying rate per day amounted to 3·9 per cent.

Inspection of Load.

At the completion of the run the load was extracted from the kiln and pushed directly into the sawmill, where four boards were taken out from various parts of the load. Two of these boards were first planed on one side to show if any movement would take place and then on the other. The remaining two boards were deep cut through the centre. This is one of the most severe tests the wood could be put to, since it would reveal at once the presence of any stresses that, though in existence, do not show up on the entire board owing to the stresses on the one side counterbalancing those on the other: the unbalancing of these stresses through the board being sawn in this manner would cause it to warp as soon as sawn. The sawn boards, however, showed no signs of warp.

The removal of the load from the kiln and testing of the boards was witnessed by several members of the Railway Administration and the Forest Department. The load itself showed no signs of splitting and only a very small amount of warp, that would not interfere with the use of the boards in the least.

All the sample boards extracted from the load stood up well to the square, and seemed quite satisfactory in other respects.

The run was considered very encouraging. At the time the truck was unloaded, each board was examined to ascertain the exact amount of defect that had taken place during the treatment. The record shows no degrade chargeable against the run.

Physical and Mechanical Qualities of the Wood.

The falcate yellow-wood is of a dull yellowish colour, interrupted at times by brownish streaks running longitudinally through the wood. The colour is considerably darker than that of the common yellow-wood (*Pod. elongata*), but resembles the shade of real yellow-wood (*Pod. thunbergii*) very closely.

The wood is non-porous and non-resinous, of a very homogeneous nature throughout, showing hardly any difference between heart and sapwood and with very indistinct annual rings.

It has a specific gravity at 7 per cent. moisture-content, of 0·55 corresponding to a weight of about 34 lb. per cubic foot, which places this wood in the fairly light class with other conifers.

The falcate yellow-wood is considerably harder than deal or imported pine, but it is not a typical hardwood by any means, and should rather be considered a medium softwood. Mr. H. G. Fourcade

Final Condition of Samples.

No.	Per Cent. Moisture-Content.				Shrinkage (per cent).
	Whole Test (Section A).	Surface Test (Section B).	Centre Test (Section B).	Difference between Surface and Centre.	
1	6·4	5·3	5·7	0·4	3·5
2	7·0	6·0	5·9	0·1	3·4
3	5·4	3·9	4·4	0·5	4·4
4	5·6	4·4	3·8	0·6	—
5	5·5	5·4	4·6	0·8	5·6
6	5·9	5·7	4·6	1·1	4·8
7	6·5	6·2	5·6	0·6	6·6
8	7·7	7·6	6·6	1·0	4·8
9	5·9	5·0	4·7	0·3	4·7
10	5·6	4·9	4·7	0·2	3·6
Average..	6·15	5·44	5·06	0·56	4·6

gave the following properties for real yellow-wood, and these are probably representative for the falcate species: relative hardness, 2·6; coefficient of elasticity, 516 tons; modulus of rupture, 2·84 tons; and crushing load, 3·15 tons per square inch.

The wood turns very well in the lathe leaving a very smooth surface, and while there was little difference between the qualities of the three yellow-woods, the falcate was placed slightly ahead of the others.

Working the wood by hand, it was

YELLOW-WOOD SEASONED IN SIXTEEN DAYS DURING FEBRUARY 1921, AT THE PRETORIA SEASONING KILNS

Truck 38380 of the South African Railways, built of the indigenous yellow-wood (*Podocarpus falcata*) and imported Baltic deal (*Pinus sylvestris*) for comparison.

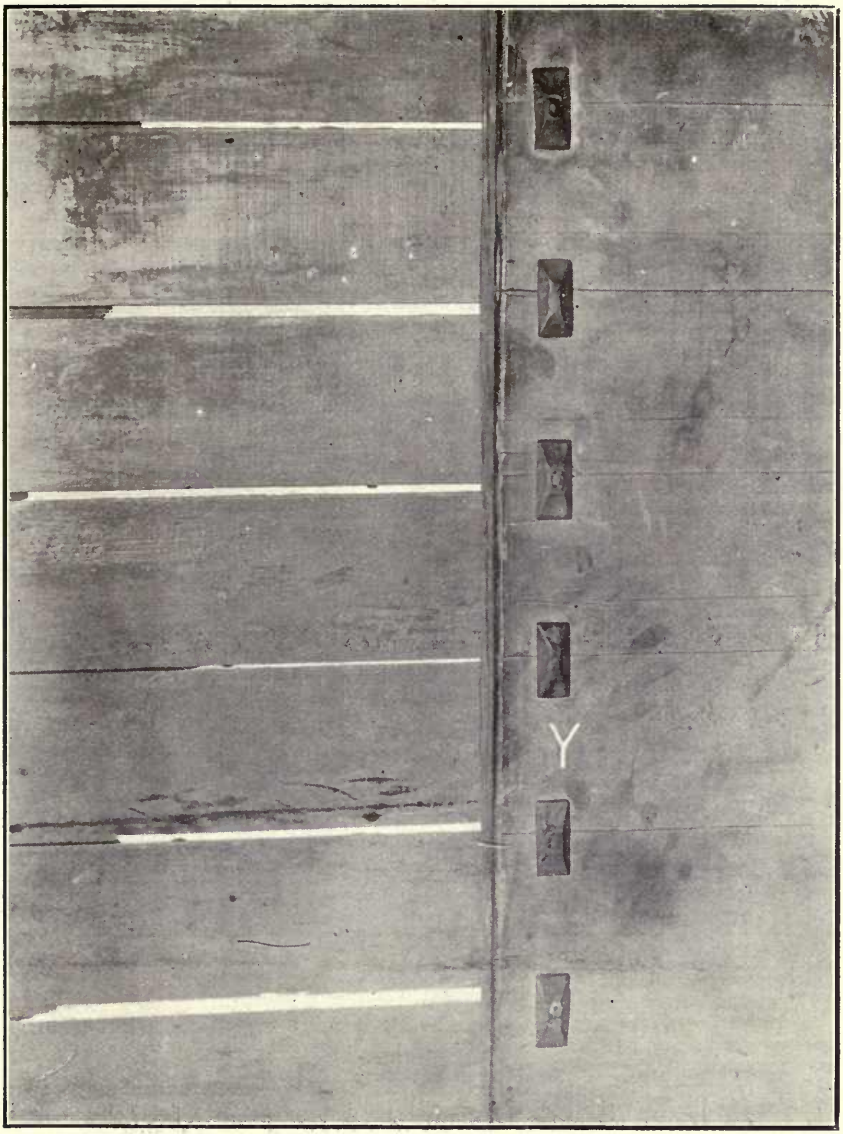
Photograph was taken after six months' service from March, 1921, to September 1921. The truck will be returned again to the Mechanical Engineer, Pretoria, for further inspection March, 1922.

The wood saws freely on a circular frame or bandsaw, either in a green state or after seasoning, and the planing machine leaves a clean smooth surface with no tearing of the grain. Passing the wood through the scraping machine will cause a very high lustre or sheen on the surface that is very attractive, but if the wood has to be smoothed by hand afterwards, it is better not to send it through the scraper because the outer surface is pressed so hard in the process that it is very difficult to remove.

found that it planed easily both with, and across, the grain, leaving a beautiful satiny finish when smoothed up. Although the wood is only medium soft, it works very nicely with all the ordinary carpenters' tools.

It takes a stain readily and may be finished with a high polish.

The nail test proved the wood to split very readily, and unless small wire-nails are used far from the ends and sides it is necessary to bore holes previous to nailing. The wood has also a tendency



YELLOW-WOOD SEASONED IN SIXTEEN DAYS DURING FEBRUARY, 1921, AT THE PRETORIA SEASONING KILNS.

Interior view of Truck 38380 of the South African Railways, built partly of the indigenous yellow-wood (*Podocarpus falcata*) and imported Baltic deal (*Pinus sylvestris*) for comparison.

Photograph was taken after six months' service from March to September, 1921.

The cracks between the boards were all filled with a white paste to denote the shrinkage of the woods.

Deal on left. Yellow-wood on right.

The widest white lines measure $\frac{1}{2}$ in. in width, and show the shrinkage of Baltic deal. No paste could be placed between the yellow-wood boards, the fine black lines being due to a slight variation in thickness of the boards.

All wood free from warp.

to split when subjected to impact, and this should be kept in mind when the wood is used.

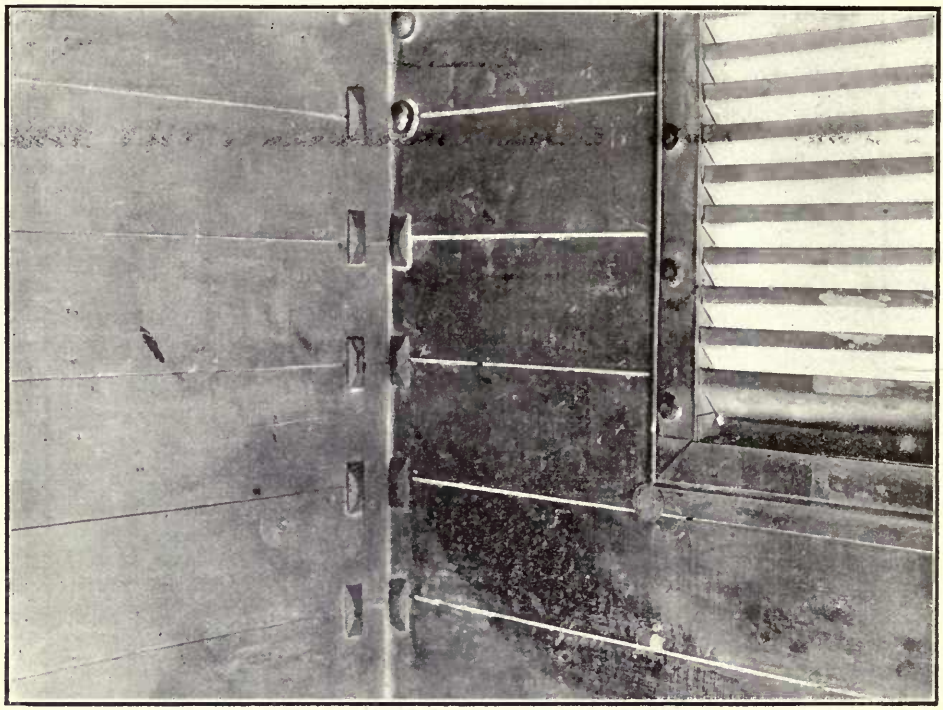
Service Tests.

The previous data show that the wood from the kiln is seasoned to a very uniform moisture-content between 6 per cent. and 7 per cent., that it is free from case-hardening, and that a careful inspection of the wood gave a very encouraging result.

While the facts deduced from the control pieces and samples, etc., are indicative of the condition of the load, absolutely conclusive proof can only be gained through service tests of the entire load.

It was therefore decided to machine the wood into $\frac{7}{8}$-in. T and G boards, and use it in the construction of the body of a closed-in goods truck. The wood machined well and no difficulty was experienced in securing the full dimension of $\frac{7}{8}$ in. from the boards that were cut green $1\frac{1}{8}$ in. The boards were free from warp and of a very good appearance.

To make a direct comparison between this yellow-wood and imported deal, which is the usual wood for this purpose, one end of the truck and the half of each



YELLOW-WOOD SEASONED IN SIXTEEN DAYS DURING FEBRUARY, 1921, AT THE PRETORIA SEASONING KILNS.

Interior view of Truck 38380 of the South African Railways, built partly of the indigenous yellow-wood (*Podocarpus falcata*) and imported Baltic deal (*Pinus sylvestris*) for comparison.

Photograph was taken after six months' service from March to September, 1921.

The cracks between the boards were all filled with a white paste to denote the shrinkage of the woods.

Deal on right. Yellow-wood on left.

The prominent white lines average $\frac{1}{8}$ in. in width and indicate the shrinkage of Baltic deal. No paste could be placed between the yellow-wood boards, the fine black lines being due to a slight variation in thickness of the boards.

All wood free from warp.

side was built of yellow-wood, and the other end and the other halves of the sides with deal.

The boards went together very well, and no extra work was involved, because the boards are all bolted on the frame, and the additional effort expended in boring holes through the slightly harder wood is negligible. The deal boards were placed in the sun a few days before being used to dry out, which is a usual practice.

When the truck was completed in the carpenter's shop, it was sent to the paint-shop, where it received the customary number of coats, numbered 38380 and stencilled :—

TIMBER TEST.

Return to M. E., Pretoria, for inspection, September, 1921 ; Ref. 3397·51.

The truck was sent into traffic in March, 1921, to be returned, as indicated, in six months. The accompanying photograph was taken in September, 1921, when it reached Pretoria after six months' use, and after it was restencilled to return in another six months, March, 1922.

The two interior views were taken at the same time, and illustrate the relative shrinkage of the two woods very clearly. The average opening between the deal measured $\frac{1}{8}$ in. with a maximum of $\frac{1}{2}$ in. The effect of this shrinkage is very detrimental to the truck, because it allows moisture to enter between the boards, starting decay in the wood. In the extreme cases of shrinkage, or when the tongue is broken off, rain may enter the truck and damage the contents. When a truck becomes too bad, it has to go to the carpenter's shop to have enough new boards inserted to take up the slack, and is then reclamped and repainted. In addition to the cost of repair should also be added the indirect cost of holding up rolling stock.

The condition of the yellow-wood boards may well be judged from the photographs. The boards were found to be in the same condition as when they were first placed and only in rare instances could a piece of paper be slipped in between them.

Considering that the deal had probably two years or more of air-seasoning, and the yellow-wood was seasoned from the green log in sixteen days with two more days for conditioning, the superior conditions of the yellow-wood after passing through six months of the dry season is very significant.

The truck is again in traffic, and will be returned once more to Pretoria, March, 1922, for further inspection.

Present and Future Utilization.

Falcate yellow-wood is used chiefly for building purposes : flooring, ceiling, shelving, and dimension stock, but it is also used by wagonmakers, for furniture, and a good many other purposes.

On account of its relative hardness compared with deal and freedom from knots, it makes a superior floor ; and its attractive appearance is a valuable asset in furniture-making.

But none of the three varieties of yellow-wood are popular among manufacturers, and the public generally steers clear of anything that savours of locally-grown wood because unreliability in service outweighs all its other good qualities and places it below the level of almost any grade of imported deal.

It is generally recognized, and the above experiment proves, that this unreliability in service is due principally to inadequate seasoning, and with the elimination of this feature the wood will naturally take its place with clear pine, yellow poplar, satin walnut, and others, for special purposes far above its present level.

Seasoning of Common Yellow-wood *(Podocarpus elongata).*

The Common Yellow-wood is also known as the Outeniqua Yellow-wood, and is well represented in many of the principal indigenous forests of the Union. It grows into a very large evergreen tree, reaching at times as much as 10 ft. in diameter and more than 100 ft. in height. It usually develops a straight cylindrical trunk that is free from branches for 40 to 80 ft., while the top is extremely straggly and usually more or less covered with drooping lichen.

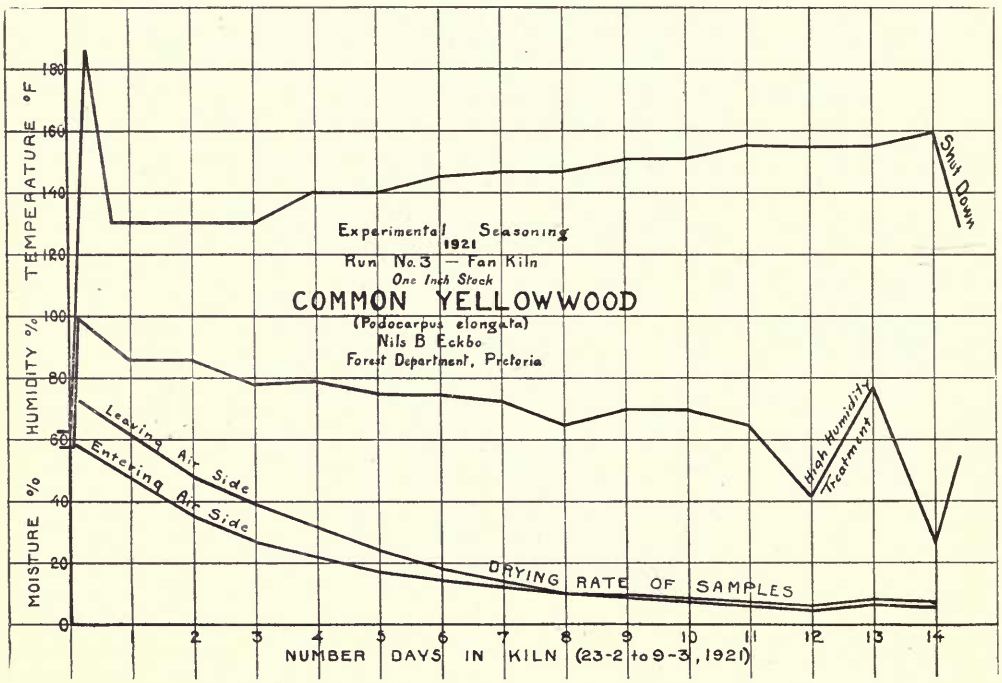
The logs received at the Pretoria seasoning kilns were cut from good average trees and arrived in a faultless condition with bark intact and ends painted to reduce drying out. They were cut into 1-in. boards, many of which presented a very rough surface due to the tearing of the fibres by the saw. Otherwise the boards had a clean appearance, being free from any defects and knots.

The boards were loaded on the kiln truck in the ordinary manner with stickers 1 in. square and $4\frac{1}{4}$ ft. long, placed 2 ft. apart between each layer of boards, so as to ensure free passage of air currents through all parts of the load; the whole forming a pile $4\frac{1}{2}$ ft. wide, 12 ft. long, by approximately 8 ft. in height. The samples about 1 in. by 12 in. by 24 in. were cut from the green boards, end-coated and weighed. One $\frac{1}{2}$-in. disc was cut from each end of these samples, weighed, then oven-dried and reweighed to ascertain its moisture-content. The average of the moisture-contents of the discs from the ends of each sample would be taken to represent the sample itself. Knowing the initial weight and moisture-content of the samples, their ultimate dry weight may then be calculated. If it is desired to find out the moisture-content of any of the samples during the run it is only necessary to reweigh them. The dry weight having been previously calculated, the moisture-content is obtained by subtracting the dry weight from the green weight, multiplying the difference by 100 and dividing by the dry weight.

The ten samples were placed in different portions of the stack and weighed every day to find out the daily rate of seasoning.

They were all cut up at the end of the run to determine if the actual moisture-content would check with the calculated moisture-content, as shown further on in the article, and also to indicate case-hardening.

In addition to calculating the daily moisture-content of these ten samples, it is necessary to keep track of the rate at which moisture is being passed off from the centre of the wood to the surface and to know if any stresses necessitating steaming treatment are developing in



the wood as it dries. For this purpose a number of control pieces were included in the load and one or more cut up every few days during the run to obtain the required information.

The data obtained from these sample pieces and control pieces is of great importance because they determine the temperatures and humidities to be applied to obtain the best results during a run of this species. A schedule worked out from these figures may easily be duplicated without the frequent use of samples and cutting of control pieces; but a check test on any load at the completion of the seasoning period is always desirable to eliminate guess work.

The seasoning of the Common Yellowwood commenced in the Sturtevant fan kiln on 23rd February, 1921. The load received an initial steaming of one hour at 185° F. and was then allowed to come down gradually to 130° F. and 86 per cent. humidity. These conditions were gradually made more severe and during the first seven days the temperature was increased to 145° F. and the humidity reduced to 72 per cent. This caused the samples to drop in moisture-content from 67·2 per cent. to 13·5 per cent., or an average of 7·7 per cent. per day, which is a very satisfactory rate of seasoning. The average shrinkage of the timber during the same period was 2 per cent. in width and 3·5 per cent. in thickness. The difference in shrinkage is due to the fact that the samples were mostly quarter-sawn, and since the shrinkage in width of a quarter-sawn board is only from one-third to one-half the shrinkage of a plain sawn board, it becomes evident that a board sawn on the quarter must have a greater amount of shrinkage in thickness than in width. Another factor that would enter into the rate of shrinkage would be the relative dimensions. A thin piece of timber would tend to show a larger amount of shrinkage because it is less liable to be set expanded.

No case-hardening was detected in the load, and the seasoning was continued for five more days, during which period the temperature was gradually increased to 155° F. and the humidity lowered to 42 per cent. In those five days the timber dried from 13·5 per cent. to 5·3 per cent. or 1·6 per cent. per day. This shows clearly how much more difficult it is to extract the last moisture from the wood than merely to reduce a high moisture-content.

The tests disclosed a considerable amount of case-hardening at this stage, and although the load was quite dry enough, it became necessary to relieve the stressed condition. Instead of affording relief by the ordinary method of steaming it was accomplished by a high humidity treatment. The temperature was kept constant at 155° F., but the humidity was increased to 77 per cent. for twenty-four hours. This caused a rapid absorption of moisture in the outer layers of the wood relieving the stress. The average moisture-content increased during the above treatment from 5·3 per cent. to 7·1 per cent., and while the latter figure was quite satisfactory, it was found that one sample was 9·9 per cent., and the load was accordingly subjected to drying for another day at 160° F. and 26 per cent. humidity. This brought down the high sample to 7·3 per cent. and the whole load was considered quite suitable for immediate use.

The copy from the daily record which follows gives the temperature and humidity condition obtained throughout the run and reflects also the effect of these conditions on the moisture-content and shrinkage of the wood.

It is of interest to note in this record that the increase of humidity from 42 per cent. to 77 per cent. on the 8th of March caused the load to pick up 1·8 per cent. in moisture-content.

A graphic statement of the temperature, humidity, and the average drying rate of the samples on either side of the load is also given.

Daily Record.

Species: Common Yellow-wood, 1 in. Run No. 3. Date: February–March, 1921.

Number of Days.	Date: February-March.	Temperature ° F.	Humidity per cent.	Treatments.		Moisture-Content per cent.	Shrinkage per cent.		Remarks.
				Hours.	° F. + Humidity per cent.		Width.	Depth.	
—	23	130	86	1	185	67·2	—	—	Runs started 1 p.m., 23rd February, and closed 1 p.m., 9th March.
1	24	130	86	—	—	—	—	—	
2	25	130	86	—	—	41·7	0·8	1·8	
3	26	130	78	—	—	33·3	1·1	2·1	
4	27	140	79	—	—	—	—	—	
5	28	140	75	—	—	20·6	1·5	2·8	
6	1	145	75	—	—	16·4	1·8	3·1	
7	2	147	72	—	—	13·5	2·1	3·5	
8	3	147	65	—	—	10·2	2·6	4·0	
9	4	151	70	—	—	9·3	2·7	4·5	
10	5	151	70	—	—	8·1	2·9	4·9	
11	6	155	65	—	—	—	—	—	
12	7	155	42	—	—	5·3	3·5	5·5	Case-hardening noticed.
13	8	155	77	24	155–77	7·1	3·5	5·5	
14	9	160	26	—	—	5·2	3·8	6·0	Removed. Samples weighed 10th.

Moisture Distribution.

The transfusion of moisture from the centre of the wood to the surface may be judged from the following data :—

Date.	Moisture Per Cent.			
	Complete Disc.	Surface.	Centre.	Difference.
February 26.....	21·6	15·6	23·9	8·3
,, 28.....	27·9	23·6	31·5	7·9
March 1.....	24·9	20·8	28·0	7·2
,, 2.....	23·7	19·8	27·3	7·5
,, 3.....	15·8	15·1	18·1	3·0
,, 4.....	10·9	11·7	11·8	0·1
,, 5.....	10·0	10·0	10·6	0·6
,, 7.....	7·2	7·3	7·8	0·5
,, 8.....	7·9	8·7	8·0	0·7

The maximum difference in moisture-content between the surface and centre of the wood was measured to be 8·3 per cent. on the 26th day of February. This difference was gradually reduced during the run and after the ninth day it became less than 1 per cent.

It may be deduced from this that a maximum difference of about 10 per cent. may have no harmful effects on the Common Yellow-wood in the early parts before being removed to the storage of the run since no splitting took place nor severe case-hardening.

Final Condition of Samples.

The kiln was closed down the 9th of March, but since the next load was not ready to go in and the material was not wanted immediately in the workshop,

the load was left in the kiln several days shed and the samples were not cut up until the 19th of March.

The following information was obtained :—

No.	Per Cent. Moisture-Content.				Shrinkage.	
	Whole Test Section.	Surface Test Section.	Centre Test Section.	Difference Surface and Centre.	Width.	Depth.
1	10·5	11·6	9·4	+ 2·2	3·7	5·9
2	11·4	11·3	10·7	+ 0·6	3·4	6·3
3	10·9	10·6	8·6	+ 2·0	3·9	5·8
4	10·1	10·8	9·0	+ 1·8	4·2	6·0
5	9·9	10·9	9·6	+ 1·3	3·8	7·9
6	10·7	11·2	10·3	+ 0·9	4·1	3·8
7	11·1	10·8	9·8	+ 1·0	4·4	6·2
8	12·2	12·8	9·4	+ 3·4	2·4	4·7
9	10·9	9·3	9·6	− 0·3	5·2	6·8
10	10·5	10·7	9·4	+ 1·3	3·2	6·2
Average	10·8	11·0	9·6	1·4	3·8	6·0

The final condition of the samples shows a considerably higher moisture per cent. than disclosed by the daily record. It was caused by a reabsorption of moisture both in the kiln where the humidity increased to the saturation point after the heating coils were turned off, and also in the open shed since the weather was very rainy at that time.

That reabsorption did take place is indicated by the greater moisture-content of the surface than the centre of all the samples except No. 9. This hygroscopic moisture passes off readily from wood that has been once thoroughly seasoned, and would have a small influence only on its serviceability for accurate work.

Inspection of Load.

A careful inspection of the load as it was extracted from the kiln revealed the wood in good condition in regard to warp and splits. One board was passed through the planing machine and it remained true. Another board was deep cut through the centre and a very slight cupping only was noticed. This was due to the moisture-content being a small amount higher on the surface and the boards straightened out later on when the moisture equalized.

No case-hardening was detected in the boards tested or in the samples cut up later on.

Each board was examined when the truck was unloaded to ascertain the amount of defect that had taken place during the seasoning treatment. The splits that had been marked prior to the run had opened up no farther, and no difference could be noted in the other defects. The record shows no degrade chargeable against the run and it may be considered satisfactory.

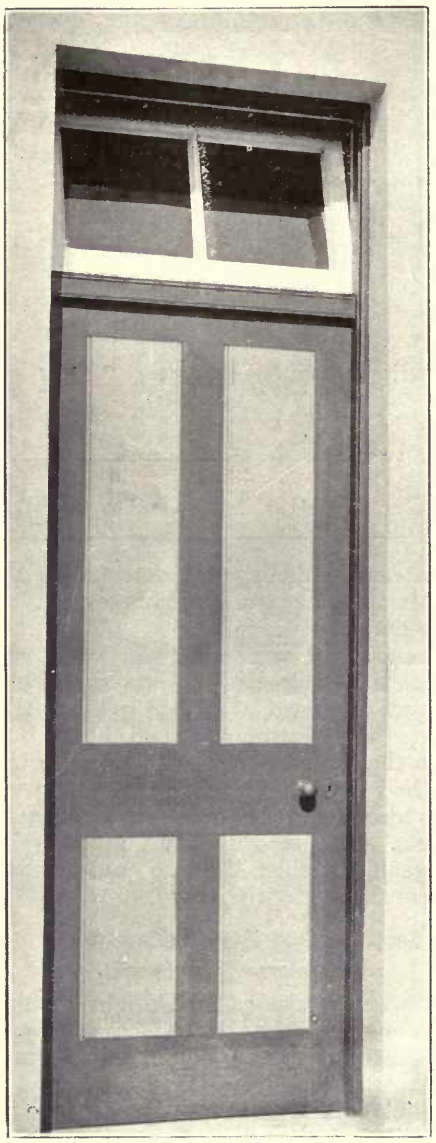
Seasoning of Real Yellow-wood

(Podocarpus thunbergii).

This tree is also called Upright Yellow-wood and by the Dutch names Regte or Oprecht Geelhout, and may be found in many forests, from the Cape Province to Zululand and from the coast to 3000 ft. in altitude. It grows like the other Yellow-woods to a large-sized tree, reaching 100 ft. in height and 4 ft. in diameter. The trunk of the tree is usually straight and free from branches for a considerable distance, but it is often more or less fluted, which causes a small amount of waste when squaring boards or planks.

The logs received at the Pretoria seasoning kilns were sawn into dimensions

varying from ¾ in. to 2 in. in depth. Several kiln runs were made, but since



This door is made from Yellow-wood seasoned at the Pretoria seasoning kilns. It is exposed to the full force of the sun's rays from 12 o'clock to sundown, and this together with the action of the drying winds, makes this test particularly severe.

the results were practically identical to those obtained with Falcate and Common Yellow-wood it is unnecessary to give any detailed account of them.

Physical and Mechanical Qualities of Common and Real Yellow-wood.

The Common Yellow-wood is usually of a bright yellowish colour with fairly distinct growth rings. The somewhat lighter colour, as well as the growth rings, help to distinguish this wood from Falcate and Real Yellow-wood; but it is not always easy to do so, because the woods resemble each other very much in other respects. The Real Yellow-wood is ordinarily of a rather dull yellowish colour with pinkish streaks frequently interspersed and the annual rings are often very difficult to detect.

Both woods are non-porous and non-resinous, showing hardly any difference between heart and sapwood. They are of a very homogeneous nature in spite of a certain amount of difference in the growth rings in the Common Yellow-wood.

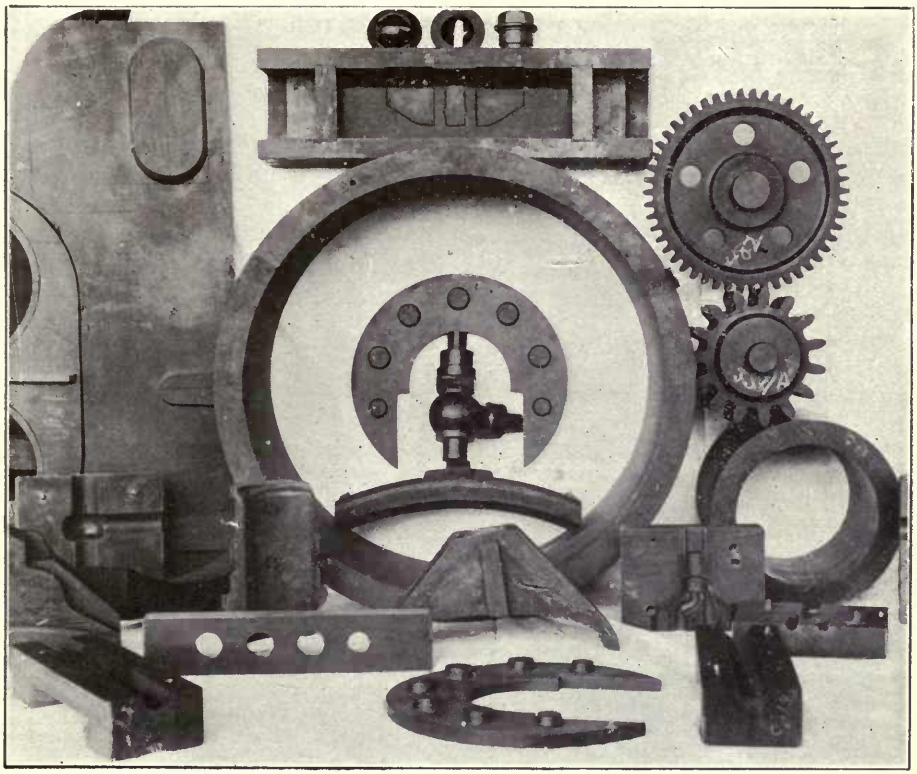
It was found that Common Yellow-wood had a specific gravity, at 7 per cent. moisture-content, of 0·54 or a weight per cubic foot of about 33 lb.; while Real Yellow-wood had corresponding figures of 0·55 and 34 lb.

The woods saw freely on a circular, frame, or band saw, either in a green state or after seasoning, but the grain of *very green* Common Yellow-wood is likely to tear, rather than make a smooth surface and in the sawdust may be found shreds of wood. This tearing of the grain does not take place with dry wood. The seasoned wood does not rough up in the planing machine, and has no special tendency to dull the knives; but passes through at the ordinary speed with a very good surface. The scraping machine leaves a very hard surface or skin that is exceedingly difficult to remove if the wood has to be smoothed by hand afterwards, and in this case it is better not to send the wood through the scraper. If the wood is not to be smoothed up by hand the high lustre or sheen left on the surface after passing through the scraper is an asset.

The wood turns very well in the lathe and resembles boxwood in appearance when smoothed up, although the growth rings show up particularly well in certain sections of Common Yellow-wood.

Working the woods by hand proved them to plane easily both with and across the grain, leaving a characteristic satinish surface when scraped and sanded. In spite of these woods being fairly hard in comparison with clear pine and deal, they worked very nicely with all the ordinary carpenter's tools. There is only very little difference in the working qualities of these two species, but the

The nail test proved the woods to split very readily and unless small wire nails are used 1 in. or more from the ends of the boards it is necessary to bore holes previous to nailing. These woods do not lend themselves readily to boxmaking for this reason; but may serve for the heavier ends of boxes where the nailing is less liable to split the wood. Both woods have a tendency



Patterns made from Yellow-wood seasoned in two to four weeks at the Pretoria seasoning kilns. It is imperative that this wood remains true in order to obtain a perfect metal casting.

Real Yellow-wood is considered slightly superior.

The natural colour of Yellow-woods is against them for many purposes where a dark wood is desired. However, they are readily stained and look exceeding well when a good grade of stain is used, and the woods are finished with a high polish. They may represent walnut or mahogany equally well.

to split when subjected to impact, and this should be kept in mind when the wood is handled in thin dimensions.

Service Tests.

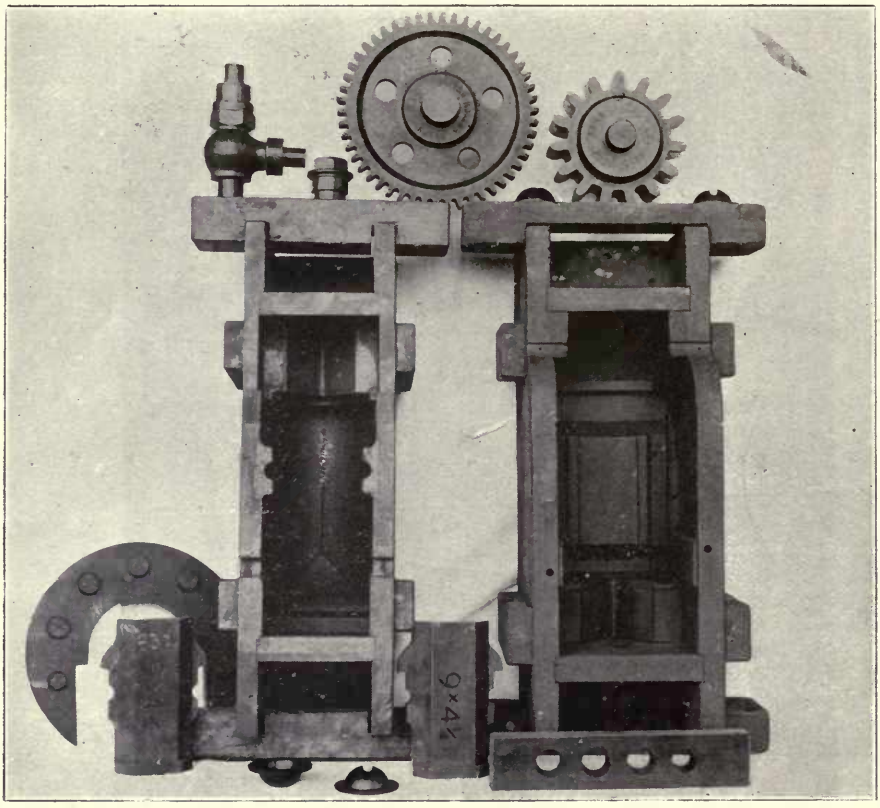
The more or less theoretical tests carried out so far have been very satisfactory in regard to moisture-content and case-hardening; but absolutely conclusive proofs of the quality of the

timbers treated can only be gained through service tests.

A small amount was used for turnery, some for panels in passenger coaches, a large amount for an order of approximately 100 all Yellow-wood doors, odd pieces of furniture, general joinery, and pattern-making.

The wood used for turnery gave satisfaction, but since the pieces were small this was no severe test, and the panels did not turn out as straight as it might ; but was all used. The carpenters and joiners found little difference between assembling Yellow-wood and clear pine except that the think skin left by the scraper was difficult to remove, and that pine wedges were superior to Yellow-wood because of their softer nature and smaller likelihood to split.

Three doors were selected at random and placed in a new office building in the



About two hundred and fifty moulds have been taken from the Yellow-wood Axle Box Pattern on the right-hand side of the photograph. It has stood the test well and may be used in the making of a good many more castings.

same may be said about the panels placed in the coaches. Making doors on the other hand is a very good trial and is fairly certain to show up defects due to bad seasoning.

The doors were standard single size for both outside and inside use. The planks were cut up accordingly, and the styles, rails, and panels kept very true. The thin moulding to be used around the workshop. One outside door facing the east, one west, and one inside door. Both outside doors had absolutely no protection from the elements, and the one facing the west is subjected to the full effect of the afternoon sun as well as the exceedingly dry and hot winds sweeping through the workshops. The door was all right for one month, when the panels commenced shrinking. Three

panels contracted about 1-16 in. after six months' service, but the fourth panel was held on the corners and, since it could not contract normally, split in the centre. This result was very interesting, because it shows clearly that wood exposed to the hot afternoon sun and drying winds must be seasoned well below 7 per cent. moisture-content to avoid further shrinkage. Absolutely no signs of shrinkage could be found in the other outside door or the inside one, and they are quite all right.

Probably the most significant test made was carried out with Yellow-wood patterns. The South African Railways and Harbours Administration has a large staff of expert pattern-makers producing wood patterns continuously. A great proportion of the metal parts of a railway train, ranging from axle boxes to door locks, are cast in a mould or matrix. A casting is made by imprinting the wooden pattern in moist sand and filling the relief with molten metal. It is evident that any imperfection in the pattern that may be caused by slight warp, shrinkage or splitting would be reproduced in the casting and render it worthless. For this reason it is of first importance to have wood for this purpose that is absolutely reliable.

A great many patterns were made of the different Yellow-woods, consisting of axle boxes, steam cock for vacuum injectors, core box for electric headlight, steam cock, axle box bearing, piston ring drum, face liner for engine axle box, core box for oil reservoir in engine, eccentric strap, top of briffault, cooking range on dining-cars, cog wheels, etc.

After six months' service the patterns are still in good condition. Two hundred and fifty moulds are reported made of a large axle box pattern, and this, as well as the other patterns, have given satisfaction and are standing well.

The other service tests, together with the service test of Falcate Yellow-wood, described above indicate clearly the possibilities of the Yellow-woods when properly seasoned, and further experimentation with these woods seems unnecessary for the time being.

While this article has dealt with the trial runs in the Sturtevant fan kiln, it should be mentioned that equally satisfactory results have been obtained with the Tieman waterspray kiln, although the drying period was slightly longer.

SEASONING OF EUCALYPTS.

Turning to the exotic species introduced in South Africa, the kinds most commonly grown are various pines, eucalypts, and wattles. Of these woods the eucalypts are by far the most difficult woods to season, and if they can be handled satisfactorily there would be good reason to believe that the others would present no insurmountable difficulties.

It is for this reason that they have been singled out for this article with special reference to *Eucalyptus diversicolor* commonly known as Karri gum.

The eucalypts as a class are not only more difficult to season than the pines and wattles, but they are universally recognized to be the most refractory woods in the world to season satisfactorily. This holds particularly in countries where these trees are introduced and utilized in an immature stage, but in Australia, which is their native land, obstacles are encountered of no mean proportions. Three years' experimentation has brought out exceedingly valuable results, but that the work is far from completed may be deducted from the fact that the Australian Government is now securing temporarily the services of the well-known authority on timber seasoning, Mr. H. D. Tiemann, of the Madison Forest Products Laboratory, United States of America.

The reasons why the eucalypts season badly may largely be attributed to (1) *a prominent initial stress* in the living tree, (2) *excessive shrinkage* that is very uneven at times, and (3) *case-hardening*. These factors cause splitting, warping, considerable reduction in volume, washboard effect from uneven shrinkage in quarter-sawn boards and honey-combing.

The initial stress in the eucalypts is a peculiar characteristic of these woods, and one that is very difficult to overcome. It does occur in other woods, but is usually so slight as to cause little inconvenience.

A striking example of the effect from this condition was noticed in a few logs of *Eucalyptus paniculata*. The tree commenced to split at the end very shortly after it was felled, and it was noticed that when the logs were cross-cut it took only five minutes for the splitting to start. It continued for about 2 in. when it seemed to stop for some time. The splits started close to the centre and opened up radially towards the surface. As the logs dried out the splitting became very much more serious.

In sawing a log lengthwise through the centre it was found that each half would turn outwards, making a gap of as much as 2 in. before the saw penetrated 7 ft. through the log; and when the log was halved completely, each half would be slightly curved like a rocker.

If, on the other hand, the log was not halved through the centre, but boards taken off from opposite sides of the log, it was noticed that when the centre portion became less than 5 in. thick end-splitting started, and by the time the centre portion had been reduced to about 2 in. the split would be approximately 2 ft. long. By turning the plank over and sawing through the centre in the plane of the split, it happened quite frequently that the plank would spring in two before the saw had penetrated much more than half the length of the plank. On the other hand, if the 5-in. plank were left to season it would eventually crack badly, and, in the case of sleepers, those with the heart of the tree in the middle of the sleeper were rendered useless, while those cut on either side of the heart behaved so much better that they could be classed as serviceable.

That the above action is actually due to a stress in the tree itself may be accepted as fairly certain, because it happened before practically any drying could take place.

The inference is therefore that in the standing tree the outside must be under tension and the centre under compression. Why this should be so is somewhat of an unsolved problem, but it is not unlikely that the outside layers of wood create the condition in an endeavour to brace the tall, slender stems against windbreak.

Shrinkage and Case-hardening.

The eucalypts are trees of extremes. As a class they are probably the fastest growing trees in the world, they hold the record for height, in hardness and strength they are surpassed by few. The wood shrinks more than most others, and the susceptibility to case-hardening is also extreme.

The shrinkage in a quarter-sawn board would probably vary from 5 per cent. to 10 per cent., while the shrinkage in plain sawn boards might run from 10 per cent. to 15 per cent., and possibly still higher. In other words, a plain sawn board, 10 in. wide, when green would only measure from 8½ in. to 9 in. when seasoned. The shrinkage is, furthermore, not even, producing at times prominent corrugations, and an additional allowance must be made for this. Under ordinary circumstances it would be well to allow not less than 20 per cent. for shrinkage in depth from the green state to the planed board and from 10 per cent. to 15 per cent. in width, depending a great deal on the method of sawing and dimensions.

The excessive shrinkage does not only reduce the volume of the material; butit is a source of danger in the utilization of the wood, because if it is used before it has reached its maximum shrinkage it is bound to cause difficulty in the manufactured product when additional contraction takes place. It is therefore of paramount importance that the eucalypts should be thoroughly seasoned.

Case-hardening is another very serious drawback with these woods, and the internal splitting or honey-combing takes place quite frequently in the larger sizes. Such material may look perfectly all right on the surface with no signs of any cracks, while the inside may be fairly riddled with splits running in a radial direction through the timber. It is caused by the setting of the outside layers of wood during the early stages of seasoning in a very expanded condition,

and when the centre portion of the wood commences to shrink normally it soon becomes held by the surface. When shrinking further, it tends to contract the outside; but since this is firml set a stress is set up in the centre that mayultimately cause the internal splitting.

The milder form of case-hardening occurs very frequently; in fact it is almost invariably present in air-seasoned stock, causing it to warp when deep cut or even planed.

Reduction in Waste from Splitting by Relieving Stress in Sawing.

In spite of the serious difficulties encountered in converting the eucalypts into commercial material, it is certainly advisable to do so if possible because of the large plantations of these trees in South Africa, their marvellous growth, and the exceptional qualities of the woods for certain purposes.

With a thorough knowledge of the conditions causing the great difficulties it should be possible to combat them, and the experiments carried out at the Pretoria seasoning kilns have already brought out some useful results.

It has been shown that the eucalypts have a strong tendency to split shortly after the trees are felled, and some of them continue splitting to such an extent as to render them worthless. A few blue-gum logs were squared into timbers about 12 in. by 12 in., and stacked for seasoning several years ago. Metal straps were nailed around the ends to keep them from splitting, and they received very careful attention.

The above timbers to-day are split and warped so badly that no merchantable material could be extracted from them.

An experiment of this kind, although unsuccessful in itself, is of great value, because it eliminates the method of seasoning blue-gum at least in large dimensions.

The waste in sawing up a badly split log is always considerable, and a series of cutting experiments were started with logs practically free from defects, in order to discover some method that would reduce the waste from splitting in particular. There are a good many methods in vogue, and they may be grouped roughly into plain and quarter sawing. Variations of the former method are most commonly employed, and the latter is only used with woods like the oaks, beech, and others, in order to show up the medullary rays or flakes to the best advantage on the radial surfaces. The complicity of this method accounts in part for the great difference in price between quarter-sawn and plain sawn oak.

The accompanying diagram gives six different methods of sawing logs with the object of reducing waste. No. 1 consists of sawing boards from opposite sides of a log until a balk of timber is left not less than 5 in. deep. The boards would have a tendency to cup towards the outside of the tree, but may be forced back by proper stacking and weighting. The 5-in. balk would be under a very severe stress, and should be cut through the centre without delay. The stress would then be relieved, and the two halves may be cut parallel to the first cuts into any dimensions desired.

Method No. 2 consists of halving the log through the centre to relieve the stress in the first cut. The halves will probably spring outwards a small amount, but with the flat side resting on the carriage and securely dogged, each half may be cut in a perpendicular direction to the centre cut. The boards will probably have a small amount of sideways twist that is not a serious drawback.

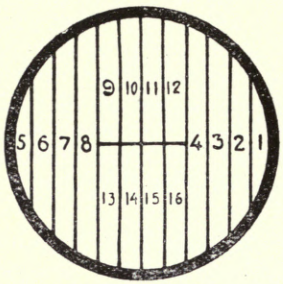
Method No. 3 is the same as No. 1, with the exception that the centre balk is cut up into boards or planks perpendicular to first cuts, commencing from one side instead of halving the balk first.

Method No. 4 is similar to No. 2, the only difference being that the log is first squared in the latter case before being sawn up.

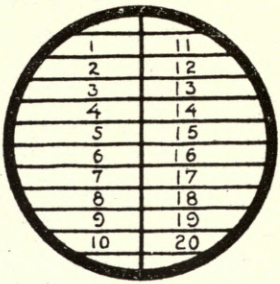
All these methods are possible with a band or a circular saw, but if a frame-saw is only available for cutting up of the logs it would be advisable to halve the centre boards or planks similarly to method No. 1 as soon as possible.

METHODS SUGGESTED FOR SAWING EUCALYPTUS LOGS TO REDUCE WASTE.

1. PLAIN SAWING. 2.

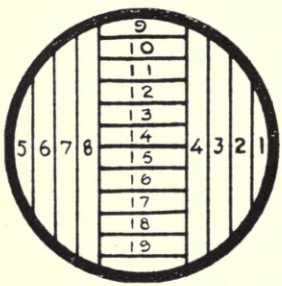


Cut away opposite sides into boards leaving centre portion 5″ deep. Halve 5″ balk lengthwise through centre and ⊥ to cut surface. Saw each half parallel to first cuts. Four planks quarter sawn (10, 11 14, 15).

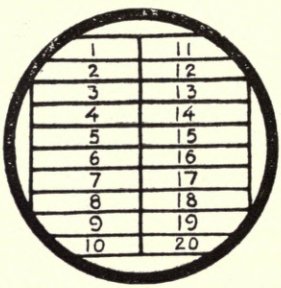


Halve the log and saw the halves any way desired. Four planks quarter sawn (5 6 15 16).

3. 4.

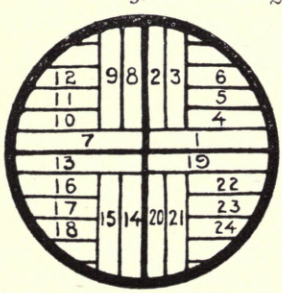


Cut away opposite sides, leaving centre portion 5″ deep. Saw this balk ⊥ to first cuts into any dimensions desired. Two planks quarter sawn (14, 15).

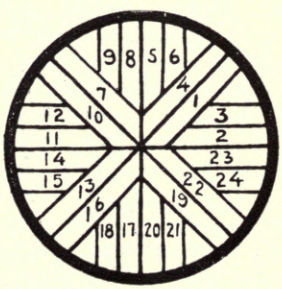


Square the log, halve the square and saw each half ⊥ or = to centre cut. Four planks quarter sawn (5, 6, 15, 16).

5. QUARTER SAWING. 6.



Saw log radially into four sections. Saw each section into planks running parallel to radial cuts. Eight planks quarter sawn (1, 2 7, 8, 13, 14, 19, 20).



Saw log radially into eight sections and each section into planks running parallel to radial cuts. Sixteen planks quarter sawn (1, 2, 4, 5, 7, 8, 10, 11, 13, 14, 16, 17, 19, 20, 22, 23).

The number of radial or quarter-sawn boards from these methods amounts to four from each log except by method No. 3, when only two quarter-sawn boards are obtained, provided in each case that the middle cut goes through the centre of the log.

In case the logs are sawn without regard to relief of the stresses a considerable loss is certain to follow in all the boards cut from the centre portion of the logs from almost immediate splitting or subsequent splitting during the seasoning.

Methods of quarter-sawing are illustrated in Figures Nos. 5 and 6, and it is the best way to relieve stress, but is hardly practicable with species that do not fetch any higher price sawn one way than the other. The number of quarter-sawn planks from the last two methods are eight and sixteen respectively.

There are several other ways that eucalyptus logs may be sawn to minimize waste, but they must depend to a great extent on the equipment available, the size of the logs, and the dimensions that are desired.

Whichever method is used, it should be remembered, as a general rule, that plain sawn boards have a strong inclination to cup; and that the quarter-sawn boards are likely to twist sideways, and, further, that the former boards will shrink almost twice as much as the latter.

Reduction in Waste from Warp and Case-hardening.

It is commonly supposed that unless eucalypts and other woods are seasoned in the log, or in large dimensions the wood will warp to such an extent as to render it useless; but exception is taken to this practice for the following reasons:

(1) Splitting from initial stress as well as continued splitting during the seasoning period causes a very serious loss.
(2) The eucalypts become so hard when dry that they are very difficult to cut up.
(3) The length of time necessary to season wood is in direct proportion to its thickness.
(4) Most woods, and eucalypts in particular, must be held straight by mechanical means, and the thinner the board the less weights are required.
(5) Case-hardening is apt to be much more severe in heavy dimensions.

It is recommended, therefore, as a general rule, to saw up the logs as soon after the trees are felled as possible into dimensions ultimately desired, making due allowance for shrinkage and warp. It is vital, however, that this recommendation be followed up by proper stacking of the timber in a suitable place immediately after the wood comes from the saw.

Experiments have shown so far that no great difficulty has been encountered in the air-seasoning of boards down to $\frac{1}{4}$ in. in thickness when these were well stacked under cover. The waste from warp and twist was by no means excessive, and the case-hardening was not sufficient to interfere with the use of the material.

It is thought that the above recommendation can be followed to advantage with most of the eucalypts when sawn into boards, planks, or dimension timbers.

In the box-shook business it might be advisable to modify the method by sawing the logs into bolts, splitting these through the centre once or twice, depending on the size of the bolt, and give these bolts or billets a certain amount of seasoning before they are cut into shooks.

KARRI SEASONED AT PRETORIA SEASONING KILNS.

(*Eucalyptus diversicolor.*)

It has been shown that splitting may be overcome to a large extent by sawing the logs so as to relieve stresses; but splitting taking place because of case-hardening during the drying period can only be eliminated by treatment in a seasoning kiln. As far as shrinkage is concerned there is little difference in the amount of this regardless of the seasoning process; but it may be possible to shrink timber more evenly in a kiln and thereby reduce warp.

In order to ascertain the feasibility of seasoning eucalyptus in a kiln an

experiment was started at the Pretoria seasoning kiln.

The species selected to begin with was Karri gum with a view to extending the experiments to other eucalypts when possible.

The Karri gum is one of the favourite trees of Western Australia, and is the second most important tree of that State. It averages about 206 ft. in height when mature, and reaches from 8 ft. to 10 ft. in diameter. The wood resembles Jarrah, but it is not durabl in the ground and does not resist termites.

The experience in Australia shows tha Karri is much more difficult to seaso successfully than Jarrah, and one singl day of low humidity is sufficient to rui a green load in a kiln. It takes from twenty-five to thirty-five days to season 1-in. Jarrah green from the saw in a kiln, while Karri, which it is said cannot be air-seasoned for the higher grades of work, can be turned out as a first-class product in thirty to forty days.

The wood is considered to be a splendid structural timber; it makes a good wagon spoke, but its main use has been for railway wagon scantling and telegraph arms. It is reported further that the sawmiller recovers from 30 per cent. to 40 per cent. of the round log (quarter girth system).

The Karri was introduced in South Africa some forty to fifty years ago, and is a tree of considerable importance in the south-western districts of the Cape Province. It is well represented in the Tokai plantations where the tree reaches a diameter of approximately 2 ft. and a height of 115 ft. in thirty years. This is a remarkably good growth that probably cannot be duplicated anywhere, except under similar climatic conditions and on equally good soil, and it is not unusual to obtain an annual yield of 300 to 400 cub. ft. of timber per acre. It was decided to make the experiment with the Karri from Tokai. A few trees were felled in autumn, cut into logs, and shipped without delay to Pretoria with ends painted and bark on. They arrived in good condition and were sawn up before much cracking had taken place.

The strength and relative hardness of this wood makes it very suitable for flooring purposes, and some of the logs were cut into 1-in. boards with the intention of machining to $\frac{3}{4}$ in. when seasoned. This is $\frac{1}{8}$ in. thinner than ordinary flooring, but it seemed warranted on account of the superior qualities of Karri for the purpose.

The boards were stacked on the truck in the ordinary manner with the usual number of samples, and run into the kiln the 10th of June, 1921. The load was steamed for two hours at 165° F., and then lowered to 115° F. with a 94 per cent. humidity. This temperature was gradually increased to 152° F., and the humidity lowered to 45 per cent., but case-hardening developed during the run and three steaming treatments were necessary to relieve it.

The load was dried from an initial moisture-content of 74 per cent. to 6·8 per cent. in twenty-nine days, or an average of 2·2 per cent. per day.

The final condition of the samples as disclosed by dissection showed that the surface contained 6·8 per cent., the intermediate layer immediately below the surface contained the same amount, and the very centre portion of the wood 7 per cent.

The average shrinkage of all the ten samples amounted to 6·8 per cent. for the quarter-sawn material, and 11·4 per cent. for the plain sawn. These figures would indicate that the timber had been sufficiently shrunk to cause little danger from further shrinkage later on.

Several case-hardening discs were cut from each sample, and they disclosed the wood free from stress.

Considering the exceptionally even moisture distribution of the load as well as the full shrinkage and freedom from stress, there is no reason to believe that it would not prove satisfactory in use.

Inspection of Load.

The appearance of the load as it was extracted from the kiln was quite good. The boards had warped but very little, and no serious corrugation could be detected.

The cracks in the end of the boards that had been marked when the truck was loaded had not extended much farther, and it would seem that most of the material could be made good use of.

Four boards were tongued and grooved, and planed down to ¾ in. in thickness. They remained true coming from the machine, and no fault could be found with the way they worked up. The same can be said of a small lot of wood that was made into picture moulding.

Physical and Mechanical Qualities of Karri.

The Karri has a fairly light colour when green, and turns darker as it dries out. When first cut after coming from the kiln the colour was bright purplish, but this seems to change gradually when exposed to the light, and turns into more of a brownish hue somewhat lighter than teak. It is a pleasing colour that would serve well in flooring without staining.

The Karri belongs to the diffuse porous woods with slightly perceptible growth rings. It is a medium heavy wood, having a specific gravity of 0·80 at 7 per cent. moisture-content, which corresponds to 50 lb. per cub. ft.

The wood saws fairly easily when green, but gets very hard as it dries out.

The seasoned wood machines without difficulty, and the roughing up of the grain, that is such a common feature with most eucalypts, is fairly rare in the seasoned Karri.

The working qualities of the wood by hand are somewhat similar to ordinary oak. The wood may be nailed without much difficulty if precautions are taken not to use too large nails close to the edge. The weight and the colour are against the wood for box-making, but where these factors are of minor importance it deserves consideration for this purpose.

The strength, hardness, and general appearance of the wood makes it particularly well suited for flooring; but it may be used for a great number of other purposes as is the case in Australia.

Service Tests.

The four boards that were turned into flooring boards have been kept in the office at the Pretoria seasoning kiln since they were milled the 12th of July. The boards have simply been pushed together and leant up against the wall without any support whatsoever to hold them together. It is now six months since the boards were milled and they have remained true; in fact, the boards may be taken apart and put together again without much trouble.

The remainder of the load was milled into ¾-in. floor-boards, and these were placed in one of the new offices in the workshops of the South African Railways and Harbours, Pretoria. The building where this floor is placed is so designed that there is an open space of about 2 ft. between the floor and the ground.

The boards were 12 ft. long and 4 in. wide. They were secretly nailed with wire nails and without boring the holes prior to nailing. Since the boards had been cut to length they were laid almost as easily as any other wood, the only difference between the Karri and deal being that the former would nail harder.

It is now about six months since the floor was laid, and there is no sign of opening up between the boards nor warping of the boards themselves. With exception of a very slight unevenness in thickness of the boards, the floor is quite as level as a good table top.

Conclusions.

It has been shown that provided the logs of Karri are sawn up quickly after felling, into pieces of small thickness, and that the latter are properly stacked, material may be obtained by air-seasoning which is serviceable for many purposes for which it is not essential that the wood should be free from case-hardening.

With kiln-seasoning, however, the wood of this species may be not only completely dried and shrunk, but also freed almost completely of internal stresses, and it can thus be rendered entirely suitable for more valuable uses, such as high-class joinery and furniture-making.

As Karri is considered in Australia to be one of the less easy woods to season,

it may be anticipated that results similar to those already obtained with this species in South Africa may also be obtained with other eucalypts produced here as well as with other classes of exotic timbers.

Seasoning Problems of the Future.

The seasoning experiments carried out so far give only an indication of what might be expected through further experimentation with other indigenous and exotic woods. The indication is promising, however, and if a sufficient number of trial runs are made it will be possible in time to work out practical seasoning schedules for the principal species in different dimensions.

It may not be necessary to make a separate schedule for each species, because it will probably be possible to group several species together under the same schedule. The various yellow-woods, for example, may all be seasoned together, while Karri, on the other hand, has to be treated entirely differently.

Wood of varying dimensions should be given individual treatment according to each size, because one plank being twice as thick as another would not only take approximately twice as long to season ; but would have to be given an entirely different treatment. In case several dimensions have to be mixed in one run, the whole load would have to be seasoned according to the heaviest dimension, which would be very uneconomical.

On account of the great number of different species growing in South Africa and the great variety of dimensions in which the woods are used, it will take a long time before even the original spade work can be completed. Some of the eucalypts in particular are so refractory that it will probably take a great many runs before practical methods may be found at all.

Giving information on kiln construction and training kiln operators should hold an important place in the future problems as being essential to the successful development of timber seasoning in South Africa. The public should be kept posted from time to time of any progress made either through the Press, by lectures, or more or less extended visits at the Pretoria seasoning kiln. In order to give a working knowledge of the methods used in operating the kilns, it is planned to extend invitation upon application by interested parties to send employees to spend from two to four weeks at the kiln, partaking in all the work in connection with one entire run if possible. The information will be given free of charge, and the necessary arrangements may be made by writing to the Chief Conservator of Forests, Pretoria.

Seasoned timber at the present time is an uncertain quantity, varying pretty much at the option of the individual and giving no protection to either producer or consumer. As a result of this there is very little, if any, difference in price between what might be considered well-seasoned and absolutely green wood. This naturally gives little incentive to the producer to season his stock, and is largely responsible for the bad repute of the local timbers.

In order to value seasoning similarly to sawing or planing timber it is essential that the definition of the word should be changed from something intangible to a definite commercial quantity capable of being determined by a simple test.

Generally speaking, wood might be considered seasoned when it does not shrink, warp or split in use, except as affected by seasonal changes. However, the merchant could not wait for his money until the wood sold had been in use long enough to demonstrate its condition, and the manufacturer on the other hand could not afford to spend considerable sums on the manufacture of the wood, and find in course of time that all efforts might have been wasted. *A method must be found therefore to decide the exact condition of the wood before it is used, for the mutual protection of all concerned.*

Such a method must be simple, and it must have a legal status before the condition of the wood can be converted into a commercial quantity, and while it may not be as easy as finding suitable ways of selling different grades of foodstuffs or wearing apparel, it can be done.

It may be accepted as a fact that if wood is uniformly dry and free from stresses the two principal causes for shrinkage, warping and splitting, have been removed, and the question resolves itself into determining these two factors.

The dryness of wood is determined by its moisture-content, and this is found by taking a small sample of the wood in any shape desirable, weigh it, place it in a warm oven until it loses no more weight, ascertained by repeated weighings, subtract the final weight from the first weight, multiply the result by 100, and divide by the dry weight. This will give the moisture-content of the wood in percentage of the dry weight of the wood.

The experiments have indicated so far that wood having been seasoned to 7 per cent. is fairly certain to give satisfaction and as far as the stresses are concerned, these can be determined by the cutting of case-hardening test pieces as previously described.

Both of the above tests are very simple and certainly more so than tests of samples made commonly with other structural commodities.

If the colonial woods were made to pass the above tests satisfactorily their subsequent behaviour could be guaranteed and it would not be long before they would take the place they deserve in South Africa. Their enhanced value would not only exceed the comparatively small additional cost of efficient seasoning, but put the taboo on green wood.

THIS BOOK IS DUE ON THE LAST DATE
STAMPED BELOW

AN INITIAL FINE OF 25 CENTS
WILL BE ASSESSED FOR FAILURE TO RETURN
THIS BOOK ON THE DATE DUE. THE PENALTY
WILL INCREASE TO 50 CENTS ON THE FOURTH
DAY AND TO $1.00 ON THE SEVENTH DAY
OVERDUE.

SEP 17 19
SEP 5 1947

LD 21–100m-7,'33

ylord Bros.
Makers
acuse, N. Y.
T. JAN. 21, 1908

YE 01350

TA422
E4
495963
UNIVERSITY OF CALIFORNIA LIBRARY